THE GLASS INDUSTRY
VOLUME 15, NUMBER 6. JULY, 1934

EFFICIENCY OF HEAT-ABSORBING GLASSES

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Editor's Note—For some time past there have been two or three heat-intercepting glasses on the market, and quite recently several other firms have gone into this field. The merits of these various glasses are a subject of some controversy, partly due to the fact that the requirements of such glasses have not been fully understood. The experience of Dr. Hampton, whose firm was one of the first in the field, will be of particular interest to our readers.

IN HIS contribution to the discussion on Mr. Hobbie's paper on "Glass for protection from 'infra-red radiation'"[3], Dr. H. P. Gage[4] mentioned the desirability of an "agreed method for evaluating the selective transmission characteristics of heat-absorbing glasses". This statement does not seem to convey what is the general need. Methods for determining transmission are already well-known, but what is needed is something analogous to an efficiency figure which would convey easily and clearly the value of any given glass considered as a medium for transmitting light and absorbing heat. This problem is not easy of solution, but the present note puts forward a suggestion for the comparison of such glasses.

There seems to be a general tendency in discussions on this subject to assume that the spectrum can be sharply divided into 'light giving' and 'heat giving' portions. This is, of course, not the case: all portions of the spectrum, ultra-violet, visible, and infra-red convey energy which, being absorbed, re-appears in the form of heat. The relative distribution of the energy emitted by the radiating body depends primarily on its temperature, the higher the temperature, the greater the proportion radiated between those wavelengths which constitute the 'visible' spectrum. This is quite apart from the enormous increase in the total radiation (which increases as the fourth power of the absolute temperature) consequent upon an increase of temperature. As an indication of the type of change which occurs, the following table may be studied. The assumption is made that all radiation of a lower wavelength than 4000 angstrom units is ultra-violet and all radiation beyond 7000 angstroms is infra-red.

Since heat-absorbing glasses are required to deal normally with solar radiation at the earth's surface, it is of interest to see how this actually does vary with wavelength. Fig. 1 shows a curve based on Langley and Abbott's data (Smithsonian Report 1903) for solar radiation throughout the spectrum. The same figure shows a dotted line the product of the energy value and the eye sensitivity curve. The resultant indicates the relative light effect on the eye of the energy in various parts of the spectrum.

From this curve, it follows (and it is also seen from the abbreviated table above) that a glass which was transparent to the visible portion of the spectrum; i.e. had a light transmission of 92 per cent—the 8 per cent being due to loss by reflection at the surfaces—and was, in addition, completely opaque to infra-red and ultra-violet, would still allow a heat transmission of about 33 per cent.

What is usually required in a heat absorbing glass for glazing purposes, is as high a light transmission as possible with the lowest possible heat transmission. There are usually other requirements too, such as those relating to the color of the transmitted light, but these may be ignored for the moment. A natural presumption is, then, that the glass having the highest value of the ratio

$$\frac{\text{light transmitted}}{\text{heat transmitted}}$$

would be the ideal for the purpose. For instance, Hobbie[3] uses this ratio as a means for estimating the value of a certain blue-green glass as compared with an ordinary plate glass. The following considerations, however, show that this criterion is not satisfactory.

A glass similar to that mentioned above, with complete transmission of light and complete absorption of radiation of wavelengths outside the visible spectrum, would, from Table I, have a ratio of 100/33=3.00 (ignoring the reflection losses). Consider now a glass with sharp cuts in the spectrum at 5000 and 6000 angstroms and having perfect transmission between these wavelengths. By integration of the curve of Fig 1 between the appropriate limits, the light transmission is found to be 65 per cent and the heat transmission is 12 per cent. The ratio is now 65/12=5.4, and by still further narrowing down the band of transmission in the

TABLE I

	Percentage of total radiation as:		
Source	*Ultra-violet*	*Visible*	*Infra-red*
Paraffin flame	nil	0.8	99.2
Gas-filled incandescent electric lamp	.4	5.6	94.0
Sun after passing earth's atmosphere	3.5	33.0	63.5
Sun outside earth's atmosphere	12.7	36.3	51.0

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[3] "Glass for protection from Infra-red radiation" E. H. Hobbie, Trans. I. E. S., Sept. 1933, p. 658.

[4] Trans. I. E. S., November 1933, p. 782.

region of 5500 angstroms while maintaining zero transmission elsewhere, a glass having a still higher value could be obtained.

Thus, reducing the light transmission by narrowing the region in which the glass does transmit, increases the ratio.

Now take the original glass of complete visible transparency and imagine the curve to be reduced to 50 per cent by halving each ordinate of the curve. Then the light transmission will be halved, but so also will the energy or heat transmission and the ratio will be unchanged. This simple ratio, then, increases for one type of alteration of the curve, and that one incidentally which modifies the color of the transmitted light, but is unchanged for the type of modification which keeps the color of the light the same. The simple criterion is thus seen to give the same numerical value in a series of glasses ranging from colorless to black, which obviously renders it of no practical value.

Our next attempt to find a basis for comparison of glasses with heat-absorbing properties, made use of a diagram in which the abscissae were the heat transmission factors (X) and the ordinates were light transmission factors (Y). The first public mention of this was made in the contribution by one of us to the discussion on a paper by English[5] before the Illuminating Engineering Society in London (England).

Fig. 2 shows such a diagram. The full line on the left represents the best possible light transmission for a given heat transmission and is derived as follows. A glass that is completely transparent throughout the whole spectrum has coordinates X=.92 and Y=.92. The 8 per cent loss is due to reflection losses. Consider now that reductions occur in the infra-red and ultra-violet regions, but that the visible portion is unaffected. Then the locus of the points representing the glasses will be a straight line parallel to the base through the point Y=.92 as far as X=.33, which corresponds with the glass which is completely opaque to all radiations outside the visible spectrum, using the somewhat arbitrary limits quoted above.

The rest of the curve is derived by assuming that the transmission curve of the glass is diminished by a vertical cut at the extremes of the visible spectrum, (A); the resultant curve represents the highest light transmission possible for a given heat transmission for the source in question, namely, the sun.

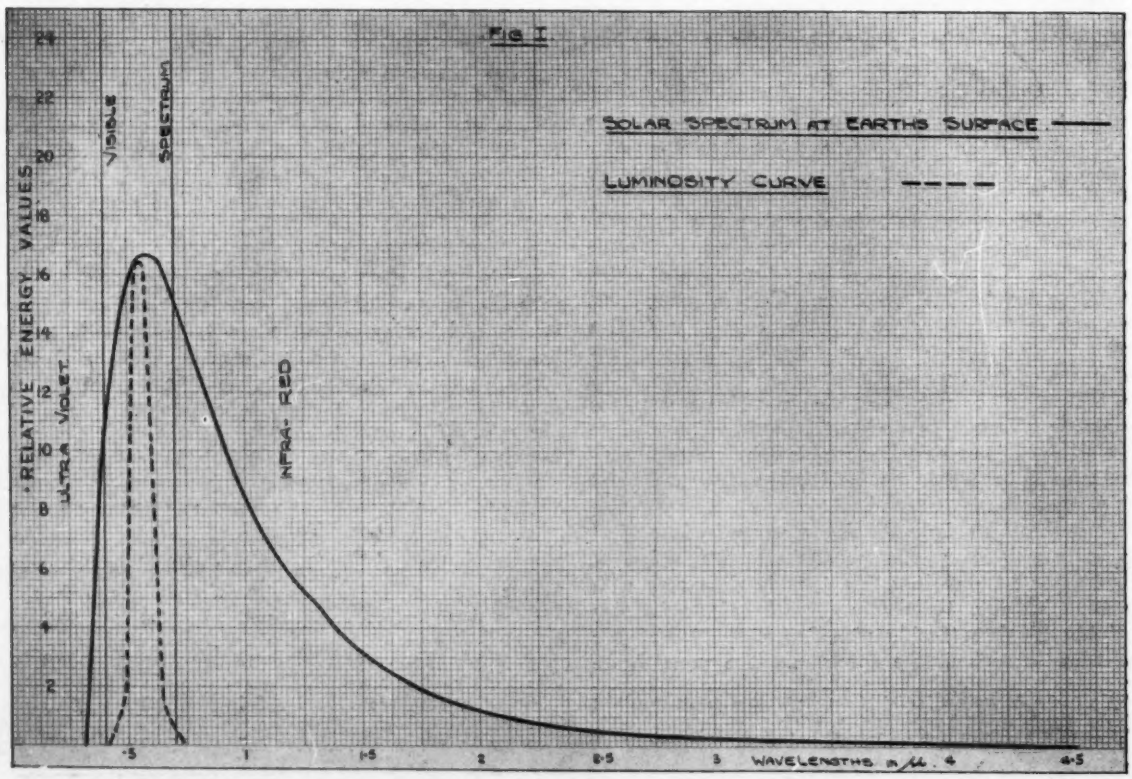
The full line on the right of the diagram gives the curve of glasses which have the lowest light transmission for a given heat transmission and is derived by the reverse of the process described above.

Then any possible glass must lie somewhere between these curved lines.

Another way of looking at this diagram is as follows. A glass with zero concentration will give the X=.92 and Y=.92 point. A glass of infinite concentration gives the X=O and Y=O point, and varying the concentration continuously gives a curve joining these two points. Then the full line curves represent the effect of increasing the concentration of two imaginary substances, each of which is the best of its kind. Any other curve derived in the same way shows the effect on the heat and light transmissions for a particular coloring material.

Now, given an assurance that the character of the absorption does not change with change of concentration, which is the case with most coloring oxides other than copper oxide, the transmission curve for any concentration can be calculated by well-known methods pro-

[5] Dr. S. English "Glasses for use with Invisible Rays" Ill. Eng., Vol. XXIV, p. 23, February 1931.



vided measured values are available for one concentration.

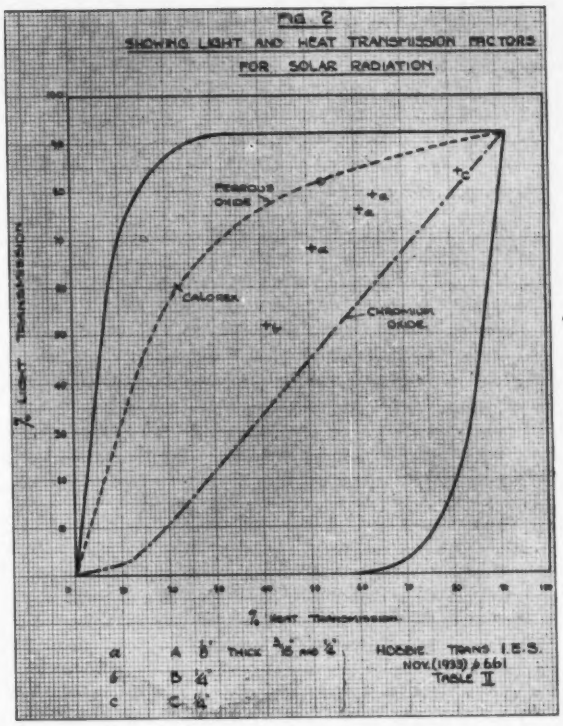
Fig. 3 shows such a transmission curve for a ferrous iron glass. From this curve, values of the heat and light transmissions for other concentrations were calculated, and these are plotted in Fig. 2 as a dotted line. The circle at X=.53 Y=.82 shows a direct determination of the transmissions for another glass similar in composition but one of a much lower iron oxide concentration. The agreement is such as to confirm the calculation which, of course, assumes no change in character with change of concentration. Similar curves can be prepared for any coloring oxide; for example, chromium oxide which gives a higher transmission in the infra-red than in the visible gives the curve shown as a chain line in Fig. 2.

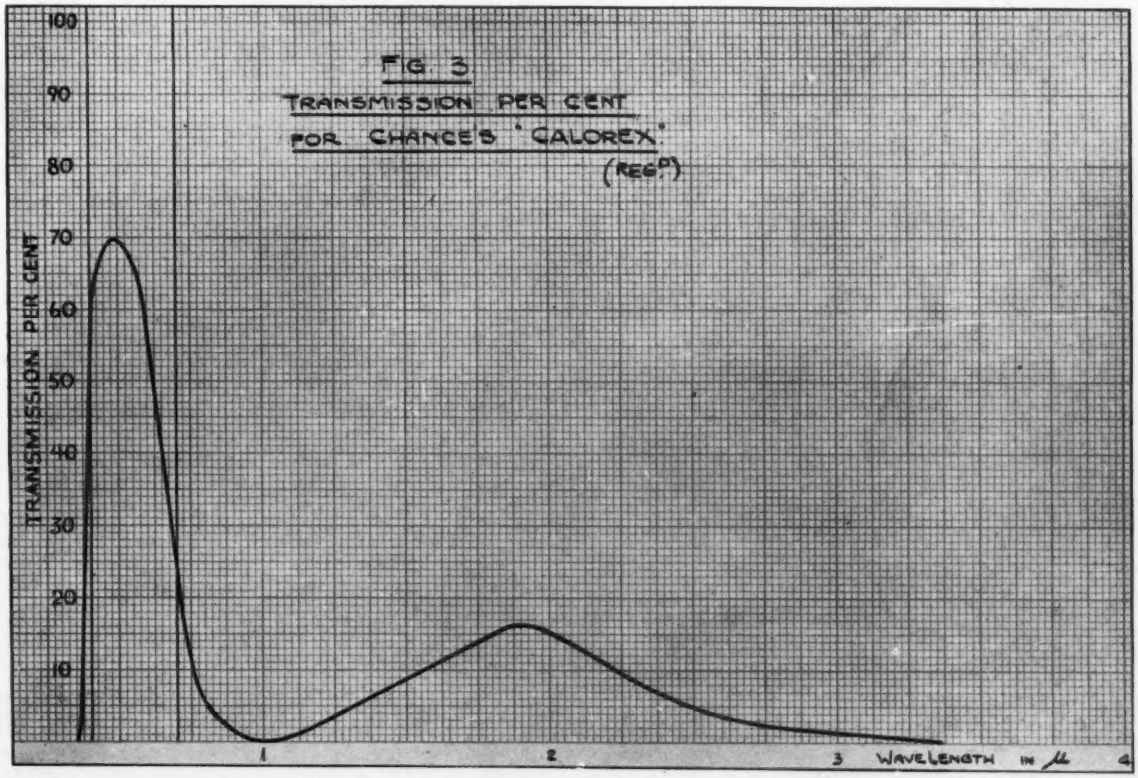
It follows from the above that a glass to give better performance than the one whose transmission curve is shown in Fig. 3, should have light and heat transmissions such that the coordinates representing it lie between the full line on the left and the dotted line in Fig. 2. So far as the authors are aware, no such glass has yet been produced. The points a, b, c, Fig. 2, represent heat-absorbing glasses whose transmissions are given in E. H. Hobbie's paper referred to above. Judged in this way, the glasses represented are less efficient than the "Calorex" curve shows to be obtainable.

The data presented in this article have been expressed in terms of solar radiation, but it is equally possible to prepare curves for any other source of radiation, such as a gas-filled incandescent electric lamp run at a specified color temperature.

The general conclusion is that it is not possible to represent the efficiency of a heat-absorbing glass by any single numerical value, but that, if the best glass is one which has the highest light transmission for a given heat absorption, then the efficiency of such a glass can satisfactorily be judged by the position of a point representing its light and heat transmissions on a diagram similar to Fig. 2.

Further, the data at present available show that iron oxide in the reduced form is the most efficient oxide for the production of heat-absorbing glasses of high light transmission. Further developments can only proceed





along the lines of more suitable bases and better chemical reduction of the iron, unless some new and unexpected coloring material be found.

OUR FRONT COVER

Our front cover picture this month is most remarkable and unusual from a glassman's standpoint in that it pictures a lake made up largely of some of the most important raw materials used in glass making. It is reproduced here through the courtesy of the American Potash and Chemical Corporation, New York City.

Searles Lake, California, is located about one hundred and eighty-five miles northeast of Los Angeles, in the northern portion of the Mojave Desert. This very unique salt deposit is of unusual interest to the glass industry inasmuch as it now supplies approximately half the world's requirements of Borax and also a moderate amount of salt cake and soda ash, the distribution of which is largely confined to the Pacific Coast.

The Lake consists of a porous crystalline mass which is permeated by a dense alkaline brine. Only during the winter, when the inflow of water is increased and the rate of evaporation is retarded, does the brine actually rise above the salt body.

The composition of the Searles Lake brine may be represented as being equivalent to the following:

Common Name	*Commercial Name*	*Per Cent by weight*
Common salt	Sodium chloride	16.35
Salt cake	Sodium sulphate	6.96
Muriate of Potash	Potassium chloride	4.70
Soda ash	Sodium carbonate	4.70
Borax	Sodium tetraborate dekahydrate	2.84
Miscellaneous		.47
Total salts (approximately)		36.02
Water		63.98

Actually the above combinations do not exist as such in the brine, and the composition will vary according to the conditions under which they are precipitated.

One of the modernistic glass murals soon to be installed in the bar of the Hotel Commodore, New York.

ROOSEVELT GETS SWEDISH VASE

A Swedish Orrefors glass vase that will shortly be presented to President Roosevelt. Etched on the panels are scenes depicting the President as a country squire as Assistant Secretary of the Navy, Governor of New York State, and as head of the New Deal.

PENN STATE TO PUSH CERAMIC STUDIES

On Saturday, June 16, a group of executives of Pennsylvania whiteware, glass, refractories, terra cotta and abrasives companies, under the leadership of President W. Keith McAfee and Secretary Ross Purdy of the American Ceramic Society, met at the School of Mineral Industries of The Pennsylvania State College with a view to considering ways and means of furthering the graduate work and research program in ceramics there. The group organized as an Advisory Board to the Department of Ceramics with Mr. Roger W. Rowland, President of the New Castle Refractories Company, as chairman and decided to petition the Pennsylvania Legislature at its next convening, January 1935 for a special appropriation for ceramics research for the next biennium. Inasmuch as Pennsylvania leads all American states in the glass industry, and as this industry is a large part of the Pennsylvania ceramic industry, the plans contemplate a considerable expansion of research and instructional facilities along these lines.

The proposed research projects to be carried on under this appropriation have not yet been definitely determined.

FURNACE CALCULATIONS

By JOHN W. ROMIG
Corning Glass Works

FREQUENTLY, information is wanted on furnace installations regarding the volume of air admitted for combustion and the volume of the products of combustion, actual per cents of excess air, et cetera. At times, a check of actual operating conditions is wanted for one reason or another and a method working out such a problem is needed. To set forth a formula is possible but very complicated, and rather than follow such procedure a step by step analysis of conditions is preferable. In order to show how air requirement for a fuel and waste gas volumes and percentages are calculated examples are shown in detail.

The example is shown for a producer gas fired glass tank. The basic information used in the glass tank calculations was secured from a tank producing glass. Through the data secured velocities in the various parts of the tank unit were checked.

Starting out with a furnace installation the first step is to secure the fuel analysis and the waste gas analysis. Enough checks of gas analyses should be made to get an average of working conditions. For the example the following analyses are taken:

Producer Gas as Analyzed		*Waste Gas as Analyzed*	
CO_2	6.98%	CO_2	15.20%
C_2H_4	0.28	O_2	5.00
CH_4	4.35	N_2	79.80
CO	22.50		
O_2	.41		
H_2	15.71		
N_2	50.31		
Moisture	7.30		

In addition to the above information one needs the coal analysis and the amount of steam blown to the producer. If velocities are to be checked, then temperatures should be taken at the points in question.

Coal Analysis

Total Carbon by Weight	69.40
H_2% by Weight	4.32
N_2 % by Weight	1.33
O_2	8.43
S	.99
Ash	8.23

B.T.U. as received 12,170 per pound

Steam blown into producer per pound of coal, .4620 lbs.

Soot and tar in producer gas .00022 pounds of carbon per cubic foot of producer gas.

Carbon in ash—11.36 per cent dry basis.

From the above it is seen that to make a real check on a producer gas fired furnace, beside temperatures, the following data are needed.

1. Coal analysis—ultimate as received.
2. Producer gas analysis.
3. Waste gas analysis.
4. Steam admitted per pound of coal.
5. Carbon in ash.
6. Soot and tar in producer gas. (This may be omitted without incurring appreciable error.)

After the data are assembled the next step is to find out how many cubic feet of producer gas are evolved from one pound of coal. This is done by balancing the carbon entering the producer and the carbon leaving the producer. At 62° F. the weight of carbon per cubic foot of carbon bearing constituent is .0317 for gases having one part of carbon and two times .0317 for gases having two parts of carbon. Using this figure and the data given the number of cubic feet of producer gas per pound of coal is computed.

Carbon Bearing Gases in Producer Gas		*Weight Carbon per Cubic Foot of Gas*
CO_2	6.98	.0698 x .0317
C_2H_4	.28	.0028 x .0317 x 2
CO	22.50	.2250 x .0317
CH_4	4.35	.0435 x .0317
Total		.01090 Pounds
Add for free carbon, soot & tar in gas		.00022 Pounds
Total Carbon in 1 Cu. Ft. of Producer Gas		.01112 Pounds

From the ultimate coal analysis it is found that one pound of coal contains .6940 pound of carbon by weight. This carbon goes into the producer gas and into the ash. The net into the producer gas is the difference between the total and the amount appearing in the ash. In the example the coal was 8.23 per cent ash by weight and the ash 11.36 per cent carbon by weight.

The carbon from one pound of coal appearing in the ash $= \frac{.1136 \times .0823}{1.00 - .1136} = .0103$ pounds.

Net carbon going into producer gas equals .6940 minus .0103 equals .6837 pound from one pound of coal. Dividing this figure by the total carbon in one cubic foot of producer gas we find that 61.5 cubic feet of dry producer gas is evolved from one pound of coal. In addition to the dry producer gas some moisture actually accompanies the gas in the form of steam from combustion in the producer and from excess steam admitted to the producer. The moisture in the air entering the producer may be neglected. This excess is computed from a hydrogen balance. One cubic foot of hydrogen weighs .00529 pound at 62°F.

Hydrogen in C_2H_4 = .0028 x 2 x .00529	
Hydrogen in CH_4 = .0435 x 2 x .00529	
Hydrogen in H_2 = .1517 x 1 x .00529	
Total hydrogen in one cubic foot of producer gas from above =	.001290 pound
Hydrogen in producer gas from one pound of coal as received = 61.5 x .001290 =	.0783 pound
Hydrogen in coal as received (from analyses) =	.0432 pound
Difference = hydrogen from decomposition of steam =	.0351 pound

The weight of steam decomposed is 9 times the weight of hydrogen or 9 x .0351 = .3159 pound per pound of coal.

"A" As there were .462 pound of steam entering the producer for every pound of coal then the weight of excess steam per cubic foot of producer gas is

$$\frac{.4620 - .3159}{61.5} = .00238 \text{ pound.}$$

"B" Moisture in the coal is 7.20 per cent by weight so $\frac{.0730}{61.5} = .00118$ pound of steam per cubic foot producer gas enters as water in the coal.

"C" Air carried in the particular tests .00049 pound of moisture per pound of coal and is included herein but may be omitted without incurring appreciable error.

From "A", "B" and "C" above the total weight of water vapor is .00405 pound per cubic foot producer gas. As one pound of steam at normal conditions has a volume of 21.004 cubic feet .00405 pound has a volume of .085 cubic feet. So every cubic foot of producer gas is accompanied by .085 cubic foot of steam.

Having the above data, the volume of gas per pound of coal and the steam accompanying the producer gas the waste gas calculations can be made. A calculation of theoretical air for complete combustion is required in addition to a calculation of the theoretical waste products of combustion.

The combustion formulaes by volume are as follows:

$$\begin{array}{ll} C_2H_4 & \begin{cases} C_2H_4 + 3O_2 = 2CO_2 + 2H_2O \\ 1 \quad + \quad 3 \quad = \quad 2 \quad + \quad 2 \end{cases} \\ CH_4 & \begin{cases} CH_4 + 2O_2 = CO_2 + 2H_2O \\ 1 \quad + \quad 2 \quad = \quad 1 \quad + \quad 2 \end{cases} \\ CO & \begin{cases} CO + \frac{1}{2}O_2 = CO_2 \\ 1 \quad + \quad \frac{1}{2} \quad = \quad 1 \end{cases} \\ H_2 & \begin{cases} H_2 + \frac{1}{2}O_2 = H_2O \\ 1 \quad + \quad \frac{1}{2} \quad = \quad 1 \end{cases} \end{array}$$

Applying these formulae to the producer gas the Table below is computed on the basis of complete combustion.

TABLE "A"

Constituent	*Producer Gas* Volume Per Cu. Ft. Producer Gas	*Theoretical by Volume per Cu. Ft. Producer Gas* O_2 Required	CO Formed	H_2O Formed
CO_2	.0698	0	.0698	0
C_2H_4	.0028	.0084	.0056	.0056
CH_4	.0435	.0870	.0435	.00870
CO	.2250	.1125	.2250	0
O_2	.0041	0	0	0
H_2	.1571	.0785	0	.1571
N_2	.5031	0	0	0
Totals	....	.2864	.3439	.2497
Deduct O_2 in Producer Gas	.0041	.0041	....	....
Totals	....	.2823	.3439	.2497
Moisture from Producer—Add	.0850	0	0	.0850
Total Net	....	.2823	.3439	.3347

As the oxygen required for theoretical combustion is .2823 cubic feet per cubic foot of producer gas the nitrogen carried in with the oxygen will be $\frac{.792}{.208}$ x .2823 or 1.0709 cubic feet. The producer gas contains .5051 cubic feet of nitrogen so the total nitrogen per cubic foot of producer gas appearing in the waste gas is 1.0709+.5051=1.5740 cubic feet.

Summarizing the volume of waste products of theoretical combustion at standard conditions we have:

H_2O	.3347	Cu. Ft. per Cu Ft. Producer Gas
O_2	0	" " " " " " " "
N_2	1.5740	" " " " " " " "
CO	.3439	" " " " " " " "
Total	2.2526	Cu. Ft. per Cu. Ft. Producer Gas

The volume of air required is equal to the oxygen required divided by .208 or $\frac{.2823}{.208}$ or 1.352 cubic feet per cubic foot of producer gas. From this figure velocities of air at observed temperatures may be computed when the fuel rate per hour is known.

We now have the theoretical products of combustion when just enough oxygen is admitted to burn the gas. We also have the waste gas analysis from the data so excess air actually admitted can be calculated.

In the complete combustion of the producer gas we start with 100 cubic feet of dry waste gas as analysed (In analyzing the waste gas with an Orsat the moisture is always condensed.) It is found that to make 100 cubic feet of waste gas as analyzed 38.62 cubic feet of producer gas are required. The calculation is as follows carrying out a nitrogen balance. The dry waste gas analysis shows:

N_2	79.80
O_2	5.00
CO_2	15.20

The extra oxygen carries with it extra nitrogen, the amount being $\frac{.05 \times .792 \times 100}{.208} = 19.10$ cubic feet per 100 cubic feet of dry waste gas as analyzed. Therefore, 79.80—19.10=60.70 cubic feet of N_2 comes from producer gas and from air needed for theoretical combustion. One cubic foot of producer gas contains .5051 cubic feet of N_2 and the air for theoretical combustion of one cubic foot of producer gas brings in 1.0709 cubic feet of N_2 so one cubic foot of producer gas brings in .5051+1.0709=1.574 cubic feet N_2 that shows up in dry waste gas.

Therefore; $\frac{60.70}{1.574} = 38.62$ cubic feet of producer gas makes 100 cubic feet of dry waste gas as analyzed at normal temperature and pressure conditions.

Actually waste gas leaving a furnace contains water vapor which is not shown in the analysis. The amount of water vapor is considerable and cannot be omitted from calculations of waste gas volumes. The water vapor comes from the producer gas and from the air supplied for combustion.

The water vapor accompanying theoretical air for combustion is calculated for average temperature and humidity conditions when gas data is taken.

The weight of dry air supplied per cubic foot of producer gas for theoretical combustion is $.07658 \times \frac{.2823}{.208} = .103$ pounds where .07658=weight of one cubic foot

of air at standard conditions and .2823 is the volume of O_2 required from Table "A" and .208=O_2 in one cubic foot of air. For temperature and humidity conditions existing when data was taken it is found from psychometric tables and charts that .01028 pound of water vapor accompanies one cubic foot of dry air.

The moisture in the air supplied is, therefore, .103 x .01028=.001064 pound per cubic foot of dry air. One pound of water vapor at 60°F. has a volume of 21.004 cubic feet, so .001064 x 21.004=.0224 cubic foot water vapor accompanies air entering for combustion. The total water vapor entering per cubic foot producer gas is .0224+.3347=.3571 cubic foot that shows up in the waste gas. There is, in addition, the water vapor with the excess air. As 5 cubic feet of O_2 are present in 100 cubic feet dry waste gas a ratio can be used for with .2823 cubic foot of O_2 above .0224 cubic foot water vapor accompanied the air, so $\frac{5.00}{.2823}$ x .0224=.39 cubic foot of moisture comes in with the excess air and $\frac{.395}{38.66}$= .00102 cubic foot of H_2O comes in with excess air for one cubic foot of producer gas.

All of the quantities have been established in the foregoing so it is necessary only to collect this information and tabulate. The H_2O total then is .3347 (Table "A") + .0224+.00010=.3571.

TABLE "B"

Theoretical Products of Combustion No Excess Air

Constituent in Waste Gas	Theoretical Waste Gas Volumes and Waste Gas Percentages per Cubic Foot of Producer Gas Volume		Percent
CO_2	.3439	(Table "A")	15.10
O_2	0		0
N_2	1.5740		69.30
H_2O	.3571		15.60
Total	2.2750		100.00

TABLE "C"

Products of Combustion with Excess Air and Dry Waste Gas Composition as Analyzed

Constituent in Waste Gas	Constituent per 100 Cu. Ft. Dry Waste Gas Volume	Actual Products in Cu. Ft. per Cu. Ft. Producer Gas. Vol.	Actual Waste Gas Analysis with Moisture Percents	Analyses Dry Waste Gas as Analyzed Percents
CO_2	15.20	.3930	13.29	15.20
O_2	5.00	.1290	4.37	5.00
N_2	79.80	2.0670	69.90	79.80
H_2O	14.24	.3678	12.44	....
Total	114.24	2.9568	100.00	100.00
Column No.	(1)	(2)	(3)	(4)

Column No. 1 information is developed as folows: the 15.2 cubic feet of CO_2, 5.00 cubic feet O_2, and 79.80 cubic feet N_2 are from the results of waste gas analyses. The water vapor is found by multiplying the amount of water vapor in waste gas per cubic foot of producer gas by the number of cubic feet of producer gas required to make 100 cubic feet dry waste gas, adding the moisture accompanying the excess air. The calculation is .3572 x 38.62+.39=14.24 cubic feet moisture at 60°F. accompanies 100 cubic feet dry waste gas.

Column No. 3 shows Column No. 1 developed on a percentage basis. Column No. 4 shows the actual data taken in analyzing the waste gas. A comparison of Columns Nos. 3 and 4 shows how widely flue gas analysis with moisture varies from actual analyses taken with an Orsat.

Column No. 2 is developed by dividing items in Column No. 1 by 38.62 for in order to secure 100 cubic feet dry waste gas 38.62 cubic feet of producer gas are required. One interesting comparison is that the CO_2 shown in Table "B" is .3439 cubic foot producer gas, while in Table "C" the CO_2 is .3930 per cubic foot of producer gas. The data were taken from a glass tank in production and CO_2 is driven off during the melting of glass batches. In this case the apparent CO_2 from the glass batch is .3930—.3439=.0491 cubic foot producer gas. This phase of the results has considerable interest in that the method of calculating waste gas constituents, volumes and percentages takes unusual conditions into consideration.

It is possible to calculate the actual percentage of excess air from the above information. In the case worked out the excess air computations are given below. The theoretical air for combustion with no excess air= $\frac{.2823}{.208}$=1.360 cubic feet per cubic foot of producer gas. With oxygen in the waste gas according to the analysis the actual air requirement equals $\frac{.2823+.1290}{208}$= 1.975 cubic feet per cubic foot of producer gas. The percentage of excess air=100 x $\frac{1.975-1.360}{1.360}$=45.5%. A simpler calculation may be made as follows: $\frac{.1290}{.2823}$ x 100=45.50%, which is merely a ratio of oxygen volumes.

The percentage of excess air is quite high in the example and with the 5 per cent flue gas oxygen per cent excess air was not considered as excessive until after the final computations were made.

Many comparisons and operating performance checks can be made by using the procedure outlined. If natural gas or fuel oil are used then the problem is much easier. Producer gas fired furnace analyses are very complicated as seen from the foregoing, and in making calculations for natural gas many computations are omitted.

Having the computed information, fuel requirement per hour and temperatures it is possible to check velocities of air, producer gas, air-producer gas mixtures and waste gas at any part of a tank installation. Heat balances may be worked out in detail both for producer and furnace. Studies of waste, heat losses and possible economies can be readily made for any installation.

The Lancaster Iron Works has installed one of their Z A G mixing units in the Ford City plant of the Pittsburg Plate Glass Company.

MECHANICAL BATCH FEEDING

THE continuous production of high quality machine fabricated glassware results from a series of operations efficiently controlled. Modernization of glass plants has placed in operation many mechanical controlling devices not the least essential of which is the mechanical batch feeder. However, this device has not apparently been fully recognized as a worthy addition to the modern plant in which automatic control is so essential.

There is only one successful method of producing glass of both high quality and low cost and that is by the strict control of all the many factors involved in the entire fabrication process. For example, in the fabrication of glass containers by the flow method it is essential that the feeder supply a constant weight glass gob to the forming machine if efficient machine operation is to result. If factors such as the furnace temperature and the glass level in the furnace are not under control the above conditions will not be fulfilled and production will suffer. Likewise the control of other factors such as excessive fuel consumption, variable tank pull and cordy glass is necessary for the continuous production of low cost quality glass ware.

In nearly every glass plant, steps are being taken to correct such factors and to improve the entire process. While many changes are being made, in many cases little or no attention is being given to the filling in of the batch. The neglect of this factor may be likened to the weak link in a chain; for in the final analysis it can be shown that the filling in operation is much more important than is ordinarily thought, as it is possible to nullify the good qualities of the improved process by the defects that are caused by the improper filling in of the batch.

The filling in of the batch to the furnace may be accomplished either manually or mechanically, the latter being the modern method. The superiority of this method for the maintenance of a controlled fabrication process over the manual method may be shown by reviewing the disadvantages of the manual method and the advantages of the mechanical method. This may be best shown by outlining what actually takes place in the furnace when either of the methods are used.

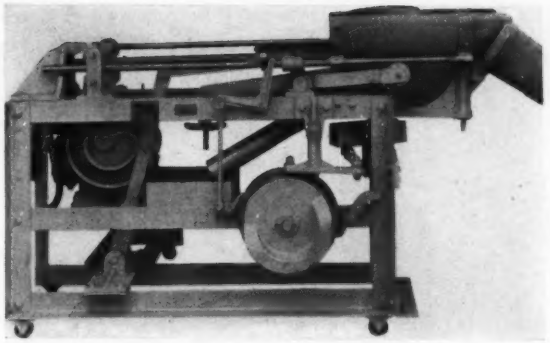
In the manual method it is customary to fill in at the time of furnace reversal, at each interval a large pile of batch being pushed into the furnace. The first effect of the entrance into the furnace of this pile of cold batch is to lower the furnace temperature with the result that the established glass flow lines and channels in the furnace are disturbed. The possibility of a periodic formation of a cordy glass condition then becomes apparent. Next, the entrance of this pile of batch will cause a surge to develop in the furnace which will be felt in the feeders and will cause both the weight and temperature conditions in the feeder to become unbalanced and upset the operation of the machine. If the flame in the furnace is close to the surface of the batch pile a considerable amount of batch will be picked up from the pile before the batch has a chance to glaze over and will be carried over into the checkers by the velocity of the flame. This batch is very corrosive on the checker brick and in time will cause sufficient clogging to necessitate a tank shut down in addition to increasing the fuel consumption.

With the manual method of batch feeding there is of course some attempt to regulate the fill with the tonnage

A Batch Feeder which operates on the screw type principle. The worm forces the batch through the tank to the melting hearth, mixing as it travels, and thus promoting segregation of the batch materials.

pull. This method however leaves this point up to the integrity of the tank teaser. Unless he is being constantly checked there is the possibility of having him adopt a schedule of change-over periods that will best fit in with his leisure time. When this is the case the tank level naturally falls very rapidly and in order to quickly bring it back up to normal, before it is noticed by those in charge, the tank teaser fills in with an excessive amount of batch. This causes the defects mentioned above to become much more serious. Even when a conscientious tank teaser is employed, an excessive amount of fill may be caused by an off calculation on tonnage being pulled or by a sudden change in pull.

When the mechanical batch feeders are used the rate of fill may be so adjusted that it exactly balances the tonnage pull. Batch surges are therefore eliminated. The mechanical feeder introduces the batch into the furnace in a thin layer which immediately becomes glazed over, thereby lessening the tendency for a large amount of batch to be carried over into the checkers by the flame. The furnace temperature is not periodically reduced, as it is when a large pile of batch is pushed into the furnace, but remains constant, with the result that the established flow lines are not radically disturbed. The exact balance between rate of fill and tonnage pull that is possible prevents any gradual change of glass level from taking place. The feeder temperatures may therefore be kept more constant and the glass depth over the orifice may be kept at exactly the proper height.



Another well known type of batch charger, a feature of whose operation is to push the batch under the mantle block in two diagonal directions, thereby automatically breaking up the streams and uniformly spreading the batch at the melting end.

This brief comparison of the two methods of feeding batch to the furnace shows that the use of the mechanical method will prove an aid in producing better glass, better working conditions, more homogenious glass, increase checker life, decrease fuel costs and in many instances decrease labor costs.

T. C. WERBE CONVALESCING

Following an illness of many months' duration, T. C. Werbe, president of the Lynch Corporation, Anderson, Ind., was taken to the Methodist Hospital, Indianapolis, on June 5 to undergo an operation. His period of convalescence is expected to be protracted and it will be some weeks before he is restored again to full health.

ON THE TRANSMISSION OF LIGHT

A recent paper* by W. L. Davies of the National Institute for Research on Dairying, England, makes a definite advance toward solving the problem of the effect of light transmitted through a wrapper or container upon the rate of the development of rancidity in oil bearing foods. Although it has been known for a long time that light accelerated the rate of spoilage of oils and fats, the recent publicity given the results of an investigation by Mr. Coe of the Department of Agriculture, has created a lively interest in the subject of colored wrappings and containers for certain foods.

Dr. Davies used for his tests milk and finely ground biscuit meal. The milk was contained in uniform soft glass test tubes which were wrapped with one layer of 300 grade Cellophane of various colors. The biscuit meal was wrapped directly in the Cellophanes. Ten colors and clear Cellophane were used; light and dark blues, light and dark greens, heliotrope, yellow, orange, pink, brown and red. The colors were all analyzed on the Lovibond scale and their transmissions chartered so they are easily reproduced.

His results show upon exposing the above materials to direct sunlight under identical conditions that the *depth* of color and not the particular color is most influential in retarding the oxidation of the fats. Deep blue, deep green, brown and red gave the best protection according to his data. It was also pointed out that the data gave evidence that maximum visible transparency combined with maximum protection might be obtained by the use of a greater thickness of a lighter shade of color, the important factors being the position of the most persistent band of light left unabsorbed. This was proven by using various thicknesses of the Cellophanes.

Although this paper appears to place the problem directly upon a basis of the amount of energy transmission through a wrapper or container the exact point where the line should be drawn so that the least harmful energy will penetrate to the contents and yet assure the maximum visibility is as yet undetermined. A statement from the Department of Agriculture (press release of May 26) claims that blue is very harmful to oils and fats. Since the analysis of the particular shade of blue which was used by the Department in making the tests upon which the statement is issued, is not available the results cannot be compared with those of Davies' above. Such a comparison would have been interesting since widely divergent results were obtained.

*Davies, W. L. J. Soc. Chem. Ind., May 18, 1934.

EARLY AMERICAN PRESSED GLASS

What is described as a very unusual exhibit of Early American pressed glass will be put on display this summer at the Thayer Museum, of the University of Kansas, Lawrence, Kansas. Founded by New Englanders, the town of Lawrence is a veritable mid-west oasis of this old ware, and it is said that more than a hundred residents have authentic collections, some of them very fine pieces. A group of twenty-five collectors have loaned their specimens to the museum.

U. S. PROPOSES DRASTIC CURBS ON LIQUOR BOTTLE MANUFACTURE

CONTROL of the manufacture and sale of liquor bottles, including all traffic in second-hand bottles, is being planned under the most drastic measures which the Federal Government has so far undertaken in its war on bootlegging. Briefly summarized, the new regulations, which the Treasury Department is expected almost hourly to announce, contain at this writing the following provisions vitally affecting the glass container industry:

1. Distilled spirits cannot be sold except in glass containers.
2. The manufacture and sale of stock liquor bottles is forbidden.
3. All liquor bottles must have certain mold marks, making liquor ware a private mold business entirely.
4. One of the mold marks required is the year of manufacture; hence molds must be changed at least every year.
5. Container capacities restricted to definite standards.
6. The jobber is eliminated from the liquor ware business.
7. Every manufacturer of liquor bottles must secure a license.
8. Bottle inventories to be reported monthly; copies of all invoices to be filed; notice given of receipt of bottle shipments.

The proposed regulations are the direct result of a survey made by the Secretary of the Treasury into the factors which permit the bootleg trade to flourish and prosper. Following this survey, both the House and the Senate passed the following joint resolution:

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, that whenever in his judgement such action is necessary to protect the revenue, the Secretary of the Treasury is authorized by the regulations prescribed by him, and permits issued thereunder if required by him (1) to regulate the size, branding, marking, sale, resale, possession, use, and reuse, of containers (of a capacity of less than five wine-gallons) designed or intended for use for the sale at retail of distilled spirits (within the meaning of such terms as it is used in title II of the Liquor Taxing Act of 1934) for other than industrial use, and (2) to require, of persons manufacturing, dealing in, or using any such containers, the submission to such inspection, the keeping of such records, and the filing of such reports as may be deemed by him reasonably necessary in connection therewith. Whoever willfully violates the provisions of any regulation prescribed, or the terms or conditions of any permit issued, pursuant to the authorization contained in this joint resolution, and any officer director, or agent of any corporation who knowingly participates in such violation, shall, upon conviction, be fined not more than $1,000 or be imprisoned for not more than two years, or both; and, notwithstanding any criminal conviction, the containers involved in such violation, shall be forfeited to the United States, and may be seized and condemned by like proceedings as those provided by law for forfeitures, seizures, and condemnations for violations of the internal-revenue laws, and any such containers so seized and condemned shall be destroyed and not sold. Any requirements imposed under this joint resolution shall be in addition to any other requirements imposed by, or pursuant to, existing law, and shall apply as well to persons not liable for tax under the internal-revenue laws as to persons so liable.

Pursuant to the above resolutions, the Treasury Department drew up the regulations reported here. As this issue goes to press, the substance but not the exact terms of the regulations are available, as these are still in the hands of the legal department. A public hearing held on June 29 might also act to modify, materially or otherwise, the regulations and possibly delay the date they are intended to become effective; namely, July 1.

The regulations are designed to:

(1) Control the supply of new liquor bottles so as to prevent these reaching the bootleggers by making it a felony with fine and imprisonment for any manufacturer of bottles, or anyone else to sell liquor bottles to anyone other than distillers, rectifiers, importers and wholesalers holding licenses from, and making bond to, the Federal Government.

(2) Control the supply of used liquor bottles so as to prevent them from reaching the bootlegger by making it a felony with fine and imprisonment, to re-sell, repurchase, possess in excessive quantities, or refill liquor bottles.

To accomplish these objectives, the regulations provide that all manufacturers of bottles used for distilled spirits will be required to obtain a license from the Secretary of the Treasury, and no one without such license will be permitted to make or to sell such bottles.

Bottle manufacturers will be prohibited from selling containers for distilled spirits to any person or concern except distillers, rectifiers, importers and wholesalers, holding licenses from, and making bond to, the Federal Government.

After a reasonable period (probably 30 days from July 1), all bottles for use as liquor containers must be made to standards of capacity and with markings prescribed by the Federal Government. These markings, which are to be blown in the bottle will include: (1) the name or registered symbol of the bottle manufacturer together with the symbol indicating the location of his plant, and the year of manufacture. (2) The name of the distiller, rectifier, importer and wholesaler for whom manufactured, or his license number or symbol, whichever the treasury department may determine upon. (3) A warning to the effect that the re-sale, purchase or use of the bottle when emptied of its original contents,

is forbidden by Federal Law, violation subject to fine or imprisonment. This caution will be reduced to a few words so that it can be readily and clearly blown in the bottle.

Distillers, rectifiers, importers and wholesalers, will be prohibited from using other containers than glass bottles in packaging distilled spirits for sale at retail, and they will be required to buy such bottles only from bottle manufacturers licensed by the Secretary of the Treasury, these bottes to be made to the capacities, and with the marking prescribed by the Government.

No distiller, rectifier, importer or wholesaler will be permitted to re-sell bottles thus purchased, or to otherwise divert them from his own use. Likewise, the importation of empty bottles for distilled spirits will be prohibited. In the case of spirits imported in bottles and cases, bottles will be required to show markings similar to those required of domestic manufacturers.

The purchase or sale of bottes for distilled spirits by any person or concern will be prohibited except as under the regulations. Re-sale, re-use or re-purchase of bottles marked as approved above, or which originally contained distilled spirits, will be prohibited. Possession in excessive quantities will be deemed prima facie evidence of illegal acquisition and intent to re-sell. Dispensers of distilled spirits at bars, restaurants, etc., will be required to serve the same from the original packages.

In order to exercise more effective control and check on these provisions, the following requirements will become effective:

(1) A certified copy of every order for liquor bottles must be furnished the District Supervisor of the Bureau of Internal Revenue at the time the order is placed.

(2) A certified copy of invoice for all liquor bottles shipped must be furnished the District Supervisor by the bottle manufacturer at the time the goods are shipped

(3) Immediate notice of receipt of consignment must be given the District Supervisor by the consignee, i.e., the distiller, rectifier, importer or wholesaler.

(4) Monthly reports will be required to be submitted to the District Supervisor by both the bottle manufacturers and the distiller, rectifier, importer or wholesaler.

Sentiment among glass container manufacturers is not entirely united in support of the new regulations. Among those who look upon them with disfavor is a group of the smaller container manufacturers. These point to the fact that the bulk of their liquor ware business is done through jobbers, and to eliminate the jobber is to eliminate the small container manufacturer from the liquor ware trade. Nor can the small container manufacturer regain this lost volume by selling the jobber's customer direct. The provisions requiring the purchaser's name, etc., to be branded into the bottle makes it automatically a private mold business, and the small rectifier ordering in less than carload quantities cannot afford mold expense.

This same school of opinion, moreover, advances the argument that these regulations will not accomplish the purpose expected of them. Bootleggers, they say, buy their bottles, not from the glass manufacturer, but from the second-hand dealer. And a mere law against traffic in second-hand bottles will be no more effective or enforceable than a law against bootleg liquor itself. The big outlet for bootleg liquor is the hotel or bar, which refills its bottles, and the regulations leave this leak untouched.

But there is a large, indeed a larger, element in the industry, which is anxious to support the government's program. These manufacturers grant that the regulations are drastic and that they seem to impose upon the glass manufacturer undue and unnecessary restrictions in that they limit the customers to whom he may sell, require him to keep records and submit to considerable surveillance and inspection. But when all is said and done, the bottle is the only absolutely indispensible item in the packaging of liquor which cannot be readily counterfeited and concealed. And if the container industry can adjust itself to the new requirements and wholeheartedly cooperate in enforcing them, it will make a most important contribution toward eliminating a traffic which is dangerous to public health, destructive of law and order, and one which deprives the government of revenue which must be offset by taxation in other directions.

Proponents of the new regulation can also defend them on grounds of pure self interest. Hotels, bars, restaurants, apartment buildings, and junk dealers, by their own testimony, are finding a large and lucrative market for second-hand liquor bottles, particularly those which originally contained well known and popular brands. This business has developed to a point where some of the larger distillers and rectifiers were considering buying back second hand bottles bearing their own brand mark in order to keep at least part of these from going into the hands of bootleggers.

Up to this time no distiller, and very few rectifiers, are using any second hand bottles. If this practice were once started it would not only reflect itself in a gradual decreased market for new containers, to the detriment of the glass manufacturer, but it would legitimatize the second hand liquor bottle business to a point where prevention of diversion of these bottles to bootleggers would be impossible.

It must be borne in mind that the bootlegger can well afford to pay more for second hand liquor ware bottles, or for new liquor bottles in imitation of well known brands, than the legitimate distiller or rectifier is called upon to pay for new glass.

LYNCH KEEPS MOVING

Lynch Corporation, Anderson, Ind., is still busily engaged in moving its equipment and that of the Miller unit into its new 625 x 110 factory building. These operations, however, are not being allowed to interfere with production, although the work is of such magnitude that 35 freight cars were required to bring the Miller equipment from Columbus, O. It is hoped that the new plant will be in full operation by the end of July. The Lynch Corporation is held in such esteem by the citizens of Anderson that a few weeks ago they tendered its officers a reception attended by 7000 people. The new Lynch factory has given the city one of the most modern manufactories in the entire state.

R. S. Goddard has moved his offices from the Grant Building to the Fulton Building, Pittsburgh.

ROUTINE ANALYSIS of Soda-Lime-Silica Glasses

THE steel analyst is noted for his speed in making a complete routine chemical analysis of his product. The glass analyst, in the analysis of even simple soda-lime-silica glasses, requires a much longer time to determine approximately the same number of constituents. This difference in speed is due to the use of unit methods of analysis by the steel analyst while the glass analyst uses the continuous methods.

The glass analyst can cut the time required for the routine analysis of soda-lime-silica glass nearly in half by the adoption of unit methods. The following method (given in brief), using standardized methods, shows how this may be accomplished.

1. PREPARATION OF THE SAMPLE.

The glass is crushed in a mortar and sieved through brass screens. Glass grains between 20 and 30 mesh in size are used for the analysis. If the samples are weighed up immediately after crushing there is no necessity for previous drying at 110°C. If the crushed samples are allowed to stand for any length of time they should be dried at 110°C before weighing. Two samples ("A" and "B") are weighed up, "A" having a weight of exactly 1.0000 gram and "B" a weight of exactly 0.6000 gram.

2. DETERMINATION OF SiO_2 AND Fe_2O_3.

(*a*) *SiO_2*: The sample "A" contained in a platinum crucible with a tight fitting cover is fused in the usual manner with 5 gram of sodium carbonate. When cool the melt is taken up with water and concentrated hydrochloric acid and then evaporated to dryness. Take up with water and 10ml. of 1:1 hydrochloric acid. Boil and filter off the silica, ignite and weigh. Again evaporate the filtrate to dryness, bake for 1 hour at 110°C, take up with water and 5ml. 1:1 hydrochloric acid, filter and ignite as before. Add the weight of this second silica to the first to obtain the total silica content. This procedure of igniting and weighing the two precipitates separately rather than together is followed as a time saver. In routine analysis on the same type glass composition the weight of the second precipitate is fairly constant, knowing the weight of the first precipitate a fairly accurate estimate of the silica content can be drawn early in the analysis.

(*b*) *Fe_2O_3*: The filtrate from the silica is treated in the usual manner with ammonium hydroxide and methyl red. After filtering off the R_2O_3 precipitate it is dissolved in 1:1 hydrochloric acid and the iron content determined by either the colormetric method or the electrometric method. When the equipment is available the latter method is preferable.

3. DETERMINATION OF R_2O_3, CaO, MgO, Na_2O AND R_2O.

(*a*) *Solution of sample*: Sample "B" contained in a 100ml. platinum dish is treated with 10ml. of perchloride acid and 75ml. of hydrofluoric acid and evaporated. If solution is not complete more hydrofluoric acid is added. Gently ignite the residue and take up with 1ml. of hydrochloric acid and water. Make up to a volume of 150ml.

(*b*) *Na_2O*: Pipette out exactly 25ml. of this solution and evaporate to dryness in a small casserole. Ignite gently and when cool take up the residue with 1ml. of water. Add 10ml. of uranyl zinc acetate solution and proceed as in the triple acetate method for sodium.

(*c*) *R_2O_3*: The remaining 125ml. of solution is made alkaline to methyl red with ammonium hydroxide and the R_2O_3 determined in the usual manner.

(*d*) *CaO*: The filtrate from the R_2O_3 determination is acidified with hydrochloric acid, heated to boiling, an excess of ammonium oxalate added and then made alkaline with ammonium hydroxide, 5ml. in excess. Allow to settle, filter through an asbestos Gooch and determine the calcium by titration with permanganate.

(*e*) *MgO*: The filtrate is acidified with hydrochloric acid, made barely ammonical and an excess of 8-hydroxyquinoline, allow to stand 30 minutes. Filter through a Gooch. Dry at 140°C and weigh.

(*f*) *R_2O*: The filtrate from the magnesia determination is evaporated to dryness. Ignite gently. Convert the residue to sulphates and weigh as the mixed sulphates of potassium and sodium.

4. OPTIONAL METHOD FOR CaO AND MgO.

The filtrate from the R_2O_3 determination is divided into two parts. In both parts precipitate CaO as in (d) and carry one part through the usual CaO method. In the other part precipitate MgO as in (e) but instead of weighing the Magnesium precipitate it is titrated

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GLASS PLANTS FOR NEW HAMPSHIRE?

The Arts and Crafts League of New Hampshire is investigating the cost of erecting and equipping small glass plants as part of a larger program of developing "backyard industries" to make more people self-supporting. Years ago, glass was produced in New Hampshire in comparatively small quantities. The Arts and Crafts League believes that it might be possible to take advantage of this historical background to develop small plants to produce small quantities of ornamental ware for the tourist trade and for certain groups of people. The idea already has been carried out in connection with pottery, supposedly with some success.

PITTSBURGH PLATE STOCKHOLDERS

Forty-two per cent of the stockholders of the Pittsburgh Plate Glass Company are women.These women are 2122 in number and own 19.41 per cent of the total stock. The largest single investor is the Pitcairn Co., which owns one third of the company. The Pitcairn Co., manages the estate of the late John Pitcairn, former Chairman of the Board.

CONFERENCE ON GLASS PROBLEMS DRAWS MANY GLASSMEN TO U. OF I.

ALMOST successful "Conference on Glass Problems" was held last month at Urbana, Ill. under the auspices of the Department of Ceramic Engineering of the University of Illinois. Due no doubt to its central location with respect to the midwest glass industry, a registration of more than 50 individuals from eight different states was secured. Interest in the program was so pronounced that a second meeting of the kind is already under consideration, to be held in the early Fall.

Mr. C. F. Freyling gave a most interesting demonstration of the Preparation of Glass Wool. Another lecture and demonstration related to High Vacua Discharge Phenomina, by Prof. C. T. Knipp. Of general interest educationally was a visit to the Laboratories of the Department and of the Geological Survey. Monday evening the guests assembled for a dinner and social hour.

Below are given abstracts of several papers read at the meeting. Other papers mentioned by title only are intended for publication shortly in THE GLASS INDUSTRY.

The Production of Rock Wool as a Problem in Glass Technology. By Charles F. Freyling.

Rock wool consists of an aggregate of fine fibers interspersed with small beads or "shot." It is of interest to the glass technologists because each fiber is in reality an extremely thin glass rod and each shot is a minute pear-shaped glass bead. The glass differs from ordinary glass, being composed of silica, alumina, lime, and magnesia. The results of systematic studies undertaken on the production of rock wool, together with the results of a preliminary investigation of the properties of massive samples of this four-component glass, are considered.

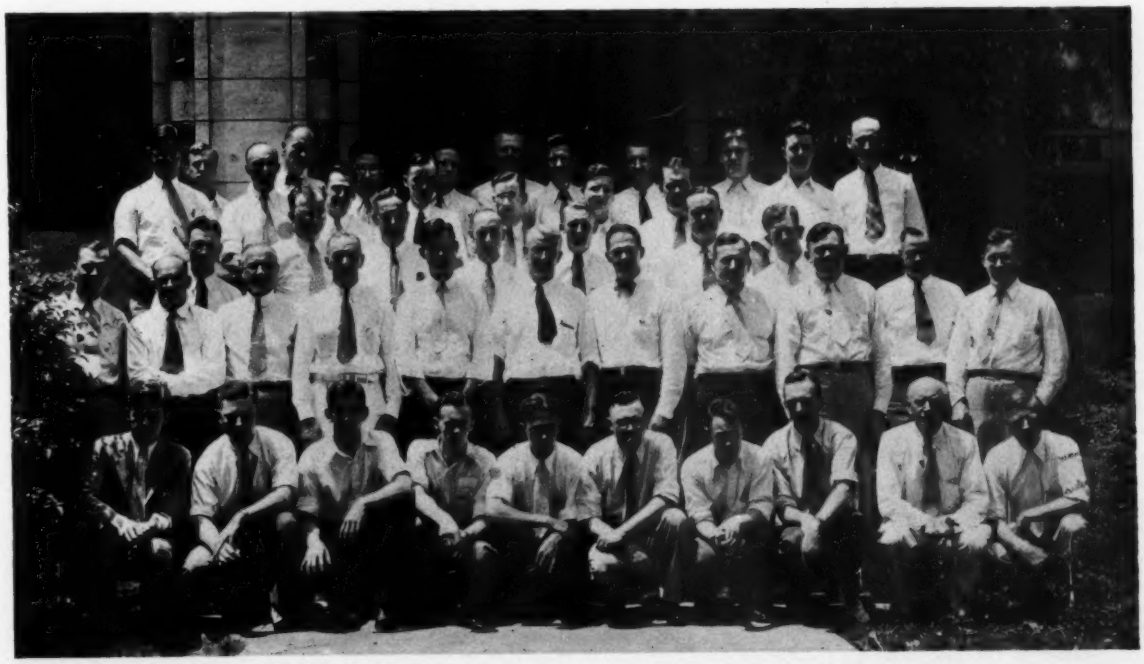
Rock wool was produced experimentally in kilogram samples by fusing woolrocks and synthetic mixtures of the four-components with an induction furnace and pouring the fluid glass into a steam blast. By this method, the influence of pouring temperature, rate of pouring, steam blast pressure, impurities, and composition, on rock wool were determined.

The quality of rock wool is determined, to a considerable extent, by the average fiber diameter of the material. The influence of composition on both the properties of rock wool and massive glass are presented by means of a series of triangular composition diagrams.

Two hundred gram samples of massive glass were prepared in fire-clay crucibles. Some of these glasses were clear, easily annealed, and exceptionally tough. Others were opal, and many devitrified badly on cooling. Glasses containing less than 65 per cent silica plus alumina could not be prepared under the conditions adopted because of excessive crucible corrosion.

The fiber diameters of the rock wool and the amount of crucible corrosion in the case of the glasses are shown by graphs to be functions of the molecular ratio of acids to bases—alumina and silica being considered as acids.

It was found that woolrocks contain from 20 to 30 per cent CO_2. This test constitutes a valuable method for the preliminary evaluation of woolrock samples. A number of such deposits have been located in Illinois.



Assembled from all over the middlewest to discuss problems of glass technology.

Surface Tension of Molten Glass by the Jaeger Method. By K. C. Lyon and C. W. Parmelee.

In this paper some of the more obvious influences of surface tension upon glass manufacturing processes were outlined. This was followed by an explanation of surface tension on the basis of the La Place theory relating surface tension to attraction between molecules in a liquid. It was pointed out that Gibbs has shown that when there is more than one kind of molecule present, the surface may be expected to have a composition different from the main body of the liquid.

From the results of studies of surface tension in soda-lime-silica glasses made by Washburn and Libman, the surface of the glass may be expected to have a lower silica content than the interior of the glass body. The same may be expected for soda-boric oxide-silica glasses in view of the results obtained in the investigation described in the paper. This condition may have a bearing upon the weathering of glass surfaces.

The methods used in the principal investigations of surface tensions of glasses were described. The Jaeger, or maximum bubble pressure method, was described in detail, the limitations and sources of error being discussed.

The average value for the surface tension of soda-boric oxide-silica glasses studied was 250 dynes per centimeter at an average temperature 1250°C. When the results were compared with the ones obtained by other investigators, it was found that those reported by Dr. Hunter on the previous day and values given by Professor Pietenpol of the University of Colorado were in satisfactory agreement.

The experimental work upon which the paper was based was carried on in the laboratories of the Department of Ceramic Engineering under the auspices of the Engineering Experiment Station.

Specific Heats of Some Commercial Glasses. By C. W. Parmelee and A. E. Badger.

Few measurements have been made on the specific heats of glasses at high temperatures. Accordingly the department has undertaken the determination of these constants for eight different glasses which have important industrial uses. The glass types include soda-lime compositions, a lead glass, a borosilicate glass and an opal glass.

The method used to determine specific heats is a modification of the so-called "dropping method," in which the glass sample in a platinum container is dropped from a furnace into a calorimeter. Mean specific heats of the glasses have been obtained up to 1050°C with this apparatus. Measurements extended from this upper temperature down to 800°C at intervals of 50°C.

The results are to be published in a forthcoming Bulletin of the Engineering Experiment Station.

The titles of other papers read included: *The Use of Alumina in Glassmaking.* By Robert F. Ferguson. *"Observations on Some Important Properties of Glass House Refractories".* By J. W. Wright. *Researches of Glass Conducted in the Department of Ceramic Engineering.* By C. W. Parmelee.

ILLUMINATING ENGINEERS TO MEET

The Illuminating Engineering Society will hold its annual convention this year in Baltimore, October 1 to 4. Outstanding features of this year's program are the Tenth Lighting Service Conference and the Lighting Equipment Exposition. These together with the technical and business sessions, inspection trips, and many social events, promise a particularly successful meeting.

NEW G. E. AUTOMOBILE INDICATOR LAMP

A new 6-8 volt indicator lamp about as large as an ordinary flashlight bulb, and designed to perform a variety of signaling services on automobiles, has been developed by the Incandescent Lamp Department of General Electric Company at Nela Park, Cleveland, Ohio.

Despite its small size, the new lamp produces one candlepower of light. Like the conventional headlight bulbs, it is equipped with a miniature bayonet base, which is an advantageous feature in providing reliable service and ease of placement.

Designated as MAZDA 51, the lamp is provided in three bulb finishes—clear, green and red. The latter finish combines red and black spray coatings, giving the lamp a mahogany color when unlighted, and brilliant but non-glaring red when lighted. This feature obviates the possibility of indecision on the part of the driver as to whether the lamp is lighted or unlighted, as might be the case sometimes if the bulb were finished with an ordinary red coating.

Among the many services for which the new lamp is applicable are: As a radio panel lamp for auto radios; as a hot-water heater switch indicator; as a light source for instrument illumination, where it will give more uniform distribution of light than present types provide; and for the following indicator services:

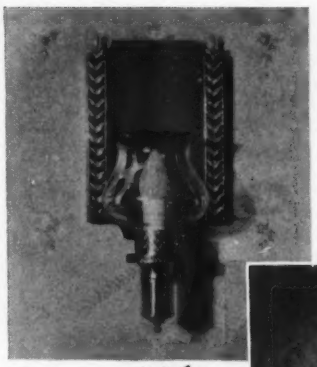
1. To indicate when the headlight clear road driving beam is on;
2. " " when the oil pressure of the motor is too low;
3. " " when the battery is discharging;
4. " " when the radiator water temperature is above the danger point;
5. " " when the gasoline level is getting low;
6. " " that the car is traveling at a rate of speed in excess of the limit set by the driver.

The lamp consumes 1/5 of an ampere. Its overall length is 15/16".

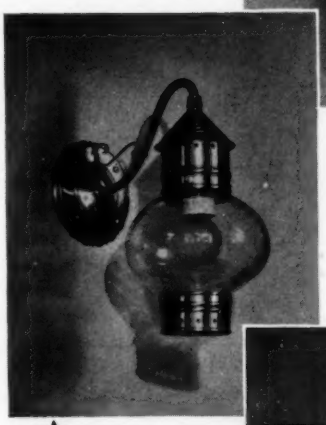
A number of car manufacturers with whom the lamp was discussed while in process of development, have indicated an intention to apply it to their next year's models.

ARCHITECTURAL COMPETITION CLOSES

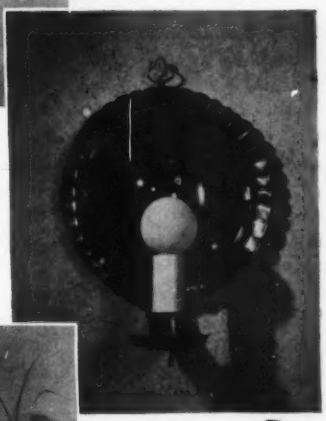
The *Pencil Points* architectural competition for the "design of a detached residence, planned for sunshine and air," closed on June 4 and the jury of awards has selected the winning designs. Announcement of the awards will be made on the July number of *Pencil Points.* This competition is being sponsored by the Plate Glass Mfgrs. of America, Window Glass Mfgrs. Association, and the Rough and Rolled Glass Mfgrs. of America.



(above) Wall brackets which reflect to perfection the symmetry and formal decoration of the Empire period (1804-1830). The laurel motif which frames the mirror and is repeated on the candle cup is particularly typical. The crystal chimney is etched by a new process.

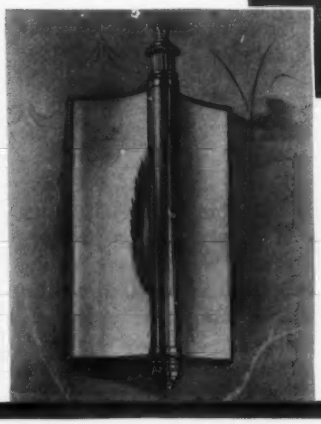


(above) An early American wall lantern (1620-1740) in which the glass preserves its irregularities of shape and texture.



(above) Another early American piece. The bull's eye reflector is made of pressed green glass, one of several special colors developed for this series.

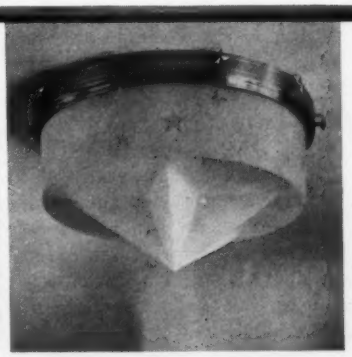
(right) A "U" shaped trough etched inside and out with a burnished silver decoration. The center bracket is molded in the glass.



LIGHTING fixtures shown here represent a remarkable cooperative achievement between the Gleason-Tiebout Glass Co., the Chase Brass and Copper Company, and Lurelle Guild, leading designer and authority on artistic periods. The fixtures are authentic reproductions of period lighting fixtures, made on a quantity basis, and sold at popular prices—on the installment plan!

Perhaps the most difficult part of the work fell upon the glass manufacturer, who was called upon to reproduce faithfully all the imperfections and characteristics of old, hand-made ware on a machine basis and at low cost. Just one problem solved by Gleason-Tiebout was to replace expensive engraving with a new etching process that in many ways is superior to engraving.

A ruby glass panel with silver etched design. Classic modern.



A star bowl of crystal glass etched inside and out. The star on the bottom is molded right on the bowl. The circumference of the bowl is frosted with stars etched clear.

BEHAVIOR OF SELENIUM IN GLASS

THE following is an abstract of a thorough-going investigation and discussion of W. Hofler in *Glastechn. Ber.*, April, 1934, pp. 117-134. The translation and abstracting for THE GLASS INDUSTRY has been done by S. R. Scholes of the N. Y. State College of Ceramics at Alfred University.

Introduction: Since about 1900 it has been known that selenium produces a red color in glass and serves to produce the most complete decolorization. Today it is the favorite decolorizer and also the most widely-used colorant. It is an exceedingly variable colorant, and requires careful handling in making crystal glass. The quantity required varies, increasing with added arsenic. Sometimes brownish effects are obtained, and no true neutrality; and the color changes on annealing or on exposure to day-light. Thus selenium has acquired a mysterious, hazy reputation, which previous scientific researches have not cleared away.

Fenaroli, in several papers in *Chem. Ztg.* in 1912 and 1914, dwelt upon the close relationship between sulphur, selenium, and tellurium in glasses. He postulated that all these elements produced a series of colors in glass, ranging from yellow to red, depending upon dispersion —redness increasing with particle-size. This view is borne out by the undoubted colloidal character of the selenium-ruby with cadmium sulphide.

Other publications on selenium colors, which have been well summarized by Zschimmer (1925) have proved none of the theories of Fenaroli. They are confined to the percentage of selenium remaining in the glass, the influence of definite batches, and similar questions. Conflicting opinions are stated. Jaeckel, *Glastechn. Ber.* 1930, emphasizes the inconclusive character of our present knowledge, when he speaks of the "Riddle of Selenium-Coloration." The character of the experimental methods of Fenaroli and nearly all other authors on this subject makes the reliability of their results questionable. Hence this investigation was undertaken.

The first melts made—in an ordinary gas-fired furnace—produced such a variety of results that it was at once apparent that much closer control would be necessary to overcome the preponderating influence of furnace atmosphere. It was decided to use an electric furnace in which any selected atmosphere could be maintained, and thus the greatest cause of variation in color due to selenium could be controlled. Simple potash-lime-silica and soda-lime-silica glasses were selected as experimental compositions.

Apparatus and Procedure : A Heraeus -Dietzel electric furnace with winding of molybdenum was used as illustrated in Fig. I.

The essential features are means for introducing pure gases or known mixtures, and for maintaining known pressures and temperatures. Porcelain crucibles composed of kaolin 60, flint 25, and feldspar 15 were found serviceable. Before each melt, the melting-space was rinsed with the gas to be used, and a slight pressure of the gas maintained during the changing operation.

About 40 g. of batch was melted at one time, in a total period of 1½ hours. Then the crucible was removed and cooled in open air—precautions as to atmosphere having been found unnecessary. It developed that the formation of layers of different colors could be more readily observed in the porcelain crucibles than in platinum. Very pure chemicals were used in the batches, and the gases applied were carefully prepared and tested for purity. The first experiments were with a potash glass, because selenium produces a livelier color in potash than in soda glasses.

Influence of Furnace Atmosphere: Conditions: parent glass: SiO_2 74 per cent, K_2O 18 per cent, CaO 8 per cent, element Selenium, equivalent to .05 per cent Na_2SeO_3; temperature of melting, 1400°C; duration 1½ hours; atmospheres: O_2, air, Ar, CO_2, H_2O, SO_2, H_2, CO, N_2 with 3 per cent CO, N_2 with 10 per cent CO.

The glasses showed great differences in color, depending upon the atmospheres in which they had been melted. Results were reproducible, in the same atmosphere, as to tint and intensity of color.

Glasses melted in oxygen are colorless in the upper third of the crucible; in the lower portion, light rose. Melts in air are similar, but the colorless layer is very shallow—a few millimeters deep—and the rose beneath is stronger. The rose color has none of the yellowish or brownish tones of commercial glasses, but almost the same tint as an acid methyl-orange solution.

In Ar, N_2, CO_2, H_2O and SO_2 the glasses were all rose, without colorless layer, but somewhat deeper in color than the lower layers in the melts in O_2 and air. Mixed N_2 and CO, 3 per cent, made the glasses somewhat brownish and salmon-colored; 10 per cent CO, still more brownish; also pure CO and H_2 made brown glasses, with a colorless layer again.

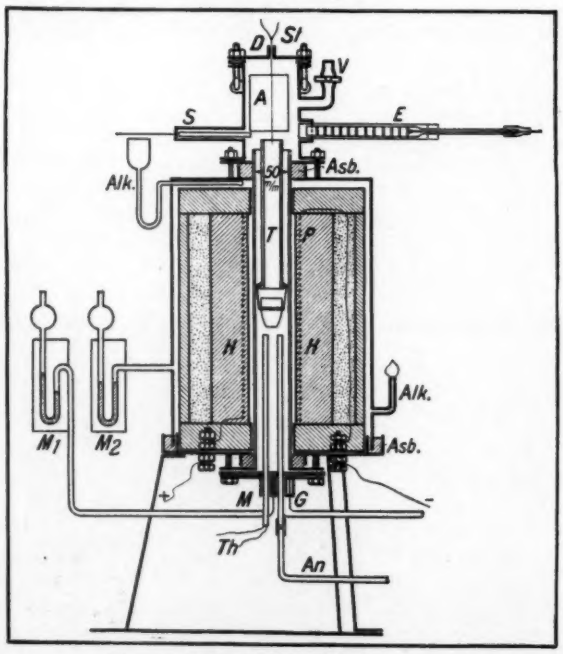


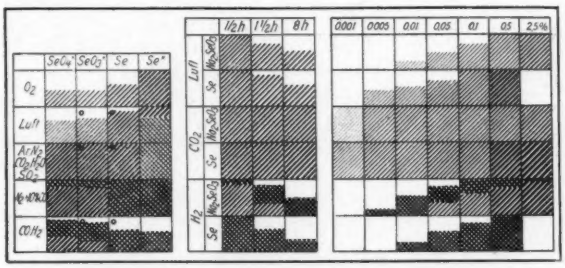
Fig. 1. Herasus-Dietzel electric furnace.

These results demonstrate the definite effects of oxidizing, neutral, and reducing atmospheres. Four effects are distinguished: a bright rose in oxidizing atmosphere, salmon-pink or brown under reduction, a colorless layer produced by oxidation, and another by reduction. It is argued that the selenium does not volatilize to produce this absence of color, else it would also volatilize in a neutral atmosphere. The writer adds that he has produced the colorless condition of selenium by strong reduction (aluminum or carbon) in a gas-fired furnace, and has demonstrated that the selenium remains in the glass, both by analysis and by re-heating colorless bits in an atmosphere suitable to produce color. The colorless forms are not identical, because their restoration to color requires respectively different treatment.

Arranged in order of decreasing oxidation and increasing reduction the effects are:

1. Colorless I.
2. Rose
3. Brown
4. Colorless IV.

It is shown in a later section that the colorless layers increase with longer exposures. That is, the 1½ hour melting time does not produce equilibrium or a final result.



(left to right) Figs. 3, 5 and 8. An explanation of these graphs is given in the text just below.

Influence of State of Oxidation of the Selenium Preparation: Studies were now made on other forms or compounds of selenium as colorants. Four steps of oxidation exist: as selenate (Se^{6+}), selenite (Se^{4+}), element selenium (Se^{0}) and selenide (Se^{2-}). The element has already been applied and its effects noted. The other forms are now introduced. The selenide, being unstable in moist air, is freshly prepared as Zn Se by precipitation with H_2Se, and used moist. Experimental conditions as before.

The results are shown graphically in Fig. 3, where the horizontal rows relate to the atmospheres used: oxygen, air, neutral gases, dilute carbon monoxide, and reducing gases. The clear spaces show colorless layers and relative depths. Diagonal ruling shows rose color —broader for greater intensity. Heavy cross-ruling indicates brown, and light cross-ruling salmon-pink.

Fig. 5 portrays the changes in coloring by selenium (.022 per cent) and by sodium selenite (.05 per cent) with varying time of melting.

Fig. 8 shows the effects of increasing the quantities of Se-reagents used in Fig. 5, all heated for 1½ hours.

The results with the different Se-reagents were consistent. The oxidized forms, selenate and selenite, extend the colorless layer formed under oxygen and air,

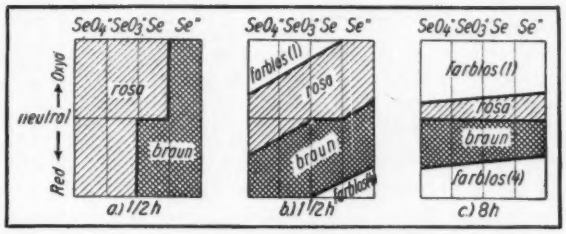


Fig. 7. Showing changes occurring in Fig. 3 when the melting time is altered.

while the selenide prevents its formation, at least in the time allowed, and in air builds a brownish (salmon-pink) lower layer. Neutral atmospheres—never forming colorless layers—produce pale pink with selenate and selenite, stronger rose with selenium element, and salmon-pink with selenide. The emphasis carries logically through the reducing series, where the colorless layer IV forms more readily as the state of oxidation of the Se goes down.

Reading down in Fig. 3, we have increasingly reducing atmospheres; reading to the right, diminishing oxygen (or positive valence) in the Se preparations. The scheme of behavior follows the plan: colorless I → rose → brown → colorless IV.

Measurements by colorimeter showed that the strongest rose is produced by element Se in neutral atmosphere, and that the brown glasses are some 20 times as strong as the strongest rose.

Influence of Melting-Time: With other conditions as in the first series of melts, the effect of ½ hour, 1½ hours, and 8 hours time under three sorts of atmospheres was next studied (Fig. 5). These melts correspond except for time with the six indicated by small rings in Fig. 3.

Lengthening of the melting-time in a definitely oxidizing or reducing atmosphere operates in the same way as raising the partial pressure of the oxidizing or reducing gas with constant melting-time. The tabular diagram in Fig. 6 represents schematically the color-changes on continued heating:

	← Oxidation		Reduction →
	Colorless I.	Rose	Brown Colorless IV
Selenite (and selenate)	←O	O	→
Selenium	←	O	O →
Selenide	←	O	O →

Fig. 6. Primary color (rings) and color-change depending upon melting-method and selenium compound used.

Selenite (and selenate, which behaves essentially the same) always produces a rose color originally, whereas element selenium is rose only in oxidizing or neutral atmosphere, and brown in reducing atmosphere. Technically this becomes important, because selenite glasses offer a certain resistance to reduction, and the undesirable brown tint produced by reduction is therefore slow to develop. This offers a reason why selenite should be preferable to selenium in practice.

The behavior of selenide is quite opposite to that of

selenite. Selenide produces at first a brown, regardless of atmosphere. Since this is not wanted, it is obvious that selenide is a poor raw material for coloring purposes. It offers a resistance to oxidation, which will turn its glass first rose, then colorless.

These resistances to reduction and to oxidation last only briefly, then the glass takes the color impressed upon it by the atmosphere in which it is melted.

Another schematic representation of the changes occurring when the melting-time is altered is Fig. 7.

Influence of Se-Concentration: Parent glass, as before, but with calcined sand. Selenium introduced as selenite and element. Quantity of Se: .001, .0025, .005, .01, .05, .1, .5 per cent, temperature 1400°; melting-time, 1½ hours; atmosphere, air, CO_2, H_2.

The results have already been exhibited in Fig. 8. The intensity of the rose color increases very slowly, in CO_2, from a synthetic value of .001 per cent Se up to the limit of 2.5 per cent. The tint remains the same and no layers form.

But in oxidizing or reducing atmospheres there is variable behavior from the beginning. In air, the glass with .001 per cent Se is colorless, faintly rose at the bottom of the crucible with .01 per cent, and builds a deeper rose layer and shallower colorless layer I with increased Se, until at .5 the colorless layer disappears.

In hydrogen the first melts were colorless (IV); a brown color appeared in the bottom of the crucible at .005 per cent Se; with increasing Se the colorless layer IV gradually shrank away, and a rose layer appeared on the bottom when .05 per cent Se was used.

Colorimetric results for melts in CO_2 and in air are set forth in Fig. 9.

Atmospheric effects are more pronounced on small Se-contents than on larger. The practical meaning of this is that the very small amounts of selenium used in decolorizing are more affected by furnace-atmosphere than are the quantities used in these experiments.

An interesting fact develops that element Se is a more powerful colorant than its equivalent applied as selenite. This has been overlooked in practice, where it is held that the selenite is more efficient because it does not volatilize as readily as Se. But it appears more logical to base the superiority of selenite on its resistance to reduction, rather than on its high coloring power.

Influence of Temperature: The usual batch with calcined sand, .05 per cent Se as selenite, was made into melts at 1200°, 1400°, and 1480°-1500°C; heated for 1½ hours under air, CO_2, or H_2.

There was some acceleration of the effects already recognized, when the temperature was raised, and the rose color was slightly paler, but for practical purposes the influence of temperature is negligible. But when a hot furnace means a bright, neutral fire, and reducing conditions accompany low temperatures, there is ground for believing that, for good decolorizing or good rose glass, a hot, clear fire is required.

Influence of Circulation of Glass: When the glass was stirred, thus bringing more of it in contact with the atmosphere, the changes in color by oxidation or reduction were greatly accelerated. But in neutral atmosphere there was no change. Since the glass is in motion in commercial furnaces, comparatively small amounts of excess air or excess fuel may be expected to affect the color.

Additions to Batch: Trials with oxidizing agents such as niter and arsenic, and with reducing agents such as carbon and aluminum, produced effects similar to those obtained by corresponding atmospheres, but more rapidly. However, they are soon consumed in the melting process, and their influence is not so continuous as that of atmosphere.

Wiegand, Dietzel, and Zschimmer have shown the presence of carbon in glass sands, and the effect of such sands is in accord with that of reducing atmosphere. The writer repeats and confirms these findings. Hence his use of calcined sand.

Notwithstanding statements in the literature to the effect that selenium must have reducing conditions to produce color, these experiments show that no reduction is necessary. Reducing agents may cause a brownish color. They do serve to counteract oxidizing atmosphere, but this condition seldom arises in practice. It is the chief aim of the manufacturer to avoid the brown color, and slight oxidation is the sure defense. This is secured by niter and arsenic. But excess must be avoided, because it leads to "striking" in the lehrs.

Speed of Cooling: Melts made as usual, some rose and some brown, were cooled in their atmospheres of melting at different rates. There were no changes in color. The contrary results of other writers are explained by the furnace atmospheres used. Times of cooling ranging from 13 hours to a few seconds showed no effect. The presence of iron oxides in the glass is held to be responsible for selenium color "striking" in the annealing process.

Time-Temperature Relationships: By maintaining bits of the glasses prepared in the different four color-steps described above, in definite atmospheres as selected temperatures for periods of time up to 24 hours, it was found that the colors changed strictly according to the course already established. The rate of change was much greater at 1400° than at 1000°, but was still noticeable at 600°. That is, in an oxidizing atmosphere colorless (IV) becomes brown, rose, then colorless (I), and in the larger pieces these changes proceed from without inwardly. In a reducing atmosphere, the reverse series of changes occur. This upsets the idea that these differences in selenium colors are due to states of dispersion, and places the cause in four different states of oxidation of selenium, to be identified a little later.

Results, I: The preceding demonstrations exhibit selenium as a sensitive colorant, as it is known to be in

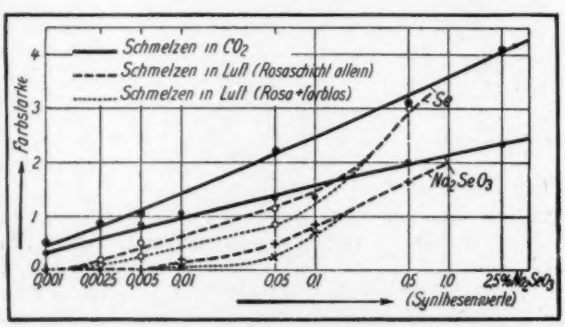


Fig. 9. Colormetric values for the Rose glasses in Fig. 8.

practice. The condition, Colorless I, is often encountered, and has been hitherto labeled "burning out". The rose color may be lighter or darker, and merges into the brown at times more or less completely. The condition, Colorless IV, can play no role in practice.

These changes, brought about by furnace atmosphere, are accelerated by intensity or concentration of oxidizing or reducing atmospheres, by low "resistance" of the Se raw material, by long melting-time, by low concentration of Se, by higher temperatures, and by rapid circulation. Batch ingredients may hasten these changes. For the clear rose color, oxidizing conditions must be present. Selenium is an indicator for atmospheres.

Influence of Composition of Glass: When K_2O-content is increased up to 22 per cent, the rose color (melting done in air) grows more intense. At 24 per cent the color begins to become yellowish, and with further increases it is more and more sallow, until at 32 per cent the glass is colorless. Greater alkalinity acts like strong reduction. Increase of CaO up to 14 per cent had a slight yellowing effect.

Potash and Soda Compared: Soda glasses produce at all stages more yellowish rose colors than potash glasses, but their behavior toward atmospheres is in no way different. When both alkalis are present, the color improves toward the "bluish" rose, even with as little as 1/10 K_2O.

Results, II: Experiments of a quantitative character are in progress, aiming to answer the question as to the chemical state of selenium in the four color-stages. At present some strong inferences may be drawn from the work already done.

Four oxidation-steps of selenium, and their probable color formations, may be tabulated:

Selenate, Se^{6+}	Element	Polyselenide	Alkali
Selinite, Se^{4+}	Selenium Se^0	Se_n^{2-}	Selenide, Se^{2-}
Colorless (I)	Red	Brown	Colorless IV

The production of rose color by use of selenite or selenate in neutral atmosphere may be attributed to partial disassociation.

Elementary selenium must enter combination with alkalis more readily in alkali-rich glasses—hence the development of brownish colors in high-potash glasses.

Conclusion: The behavior of selenium as a colorant has been shown to depend upon its state of oxidation, and not upon its degree of dispersion.

D. R. Holmes of the Fostoria Glass Company, devised this method of bringing his complete line of 2500 samples to his customers' doorsteps. It consists of a Curtiss Aerocar attached to an ordinary coupe. The inside of the aerocar (seen above) is equipped with sliding doors and satin lined drawers fitted for glass. In this way, small towns can be reached independent of transportation schedules.

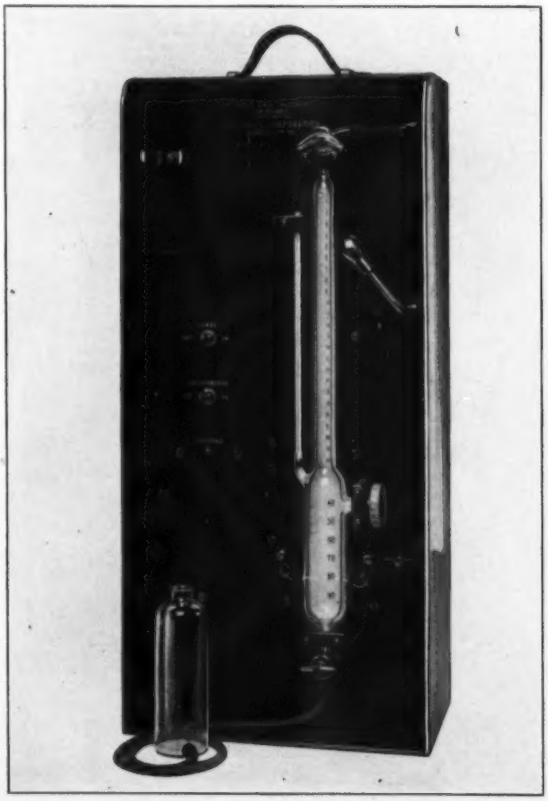
EQUIPMENT AND SUPPLIES

PORTABLE GAS CALORIMETER

A portable unit for measuring the heating value of various industrial gases has been developed by The Hays Corporation of Michigan City, Indiana. The determinations may be made without cumbersome preparations and difficult calculations. No special training is required for its operation and the results obtainable are of high accuracy. The instrument is moderately priced and instantly ready for use. About five minutes are required for the first test on any particular day but subsequent tests can be completed in from one to two minutes.

Only a small sample of gas, from 5 to 25 cubic centimeters, is required for the determination of heating value. The measured gas sample is mixed with air and exploded in a calibrated burette. The heat produced by the mild explosion is absorbed by a surrounding liquid which expands, giving a reading in a calibrated capillary tube. The ingenious design of the instrument makes it possible to carry out a parallel test with a gas of known heating value. This gas, Oxy-Hydrogen, is generated in the instrument, by the electrolytic disassociation of water. Since the two gas samples are tested under the same conditions, no corrections of any kind are necessary and the result is obtained through a very simple calculation. This calculation can be made to give the heating value either in calories per cubic meter or BTU's per cubic foot.

The use of the Hays Portable Gas Calorimeter is not confined to the determination of the heating values of gases alone. It may also be used to ascertain the amount of combustibles unburnt in whole gases; for safe guarding sewage systems by testing the explosive properties of sewage gases; for determining explosive limits of gases; for adjusting gas burners for correct air-gas mixtures, and for many other purposes.



FLANGED HEAD MOTORS

The Louis Allis Co., Milwaukee, announces the development of several types of flange head mountings for their broad line of electric motors.

The flange illustrated is an integral part of the motor head and may be finished on either or both sides. Limitations in space for motor mounting on many applications such as machine tools, including lathes, drills, grinders, polishers, etc., make it desirable to eliminate motor feet and provide finished flange on motor head for end mounting.

This new type of motor is also used widely on close-coupled pump mountings. Additional information will be sent upon request.

REPAIR MATERIAL FOR FLOORS

In a material known as "Amolastic", recently put on the market by the Floor Treatment Division of American Oil & Disinfectant Company, New York City, a way has been found to break the asphalt up into billions of particles instead of millions as heretofore, with a resultant finer emulsion that makes it possible to mix larger quan-

tities of cement, sand and gravel or trap rock, that, when applied, gives a wearing surface hard enough to stand heavy loads on steel wheels.

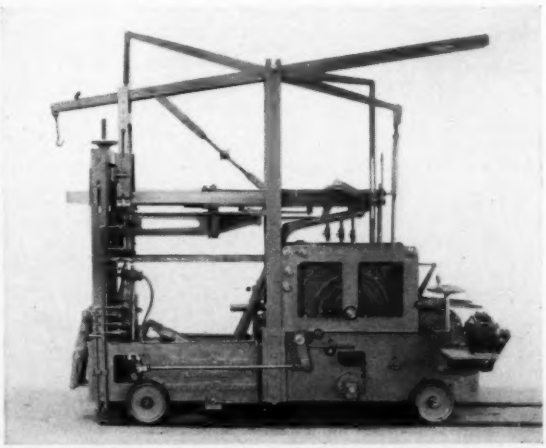
The amount of aggregate mixed with Amolastic determines the hardness to which it will set up. For foot traffic, the floor may be made soft as rubber. By merely increasing the quantity of cement, sand and gravel or trap rock, a hard, durable, wearing surface is produced for repairing and resurfacing trucking aisles, loading aprons in front of machines, platforms, boiler room floors, or wherever a smooth, skid-proof and durable surface is desired.

Amolastic will bond to all types of floors—concrete, wood, asphalt, composition or brick.

ROIRANT BOTTLE MACHINES

Great interest has been aroused among bottle manufacturers in the Roirant Single Mold Bottle Blowing Machine recently introduced in this country. This equipment has been standard in Europe for many years, where its extremely low operating cost and great versatility has enabled it to compete successfully against even the cheapest European labor. Although the Roirant machine makes no pretense of competing with American high speed machinery designed for large capacity and long runs, the manufacturer believes there is a very definite place for it here in this country on short run orders, which many of the larger plants are now obliged to decline because of the high cost attending this type of business. The fact that only a single mold is used, and the fact that molds can be changed with great rapidity and ease makes its advantages obvious.

Roirant machines are of two types: F, for ware from 2½ to 7⅞ inches in height; and B, for sizes from 6-5/16 to 14-1/8 inches high. The principle of operation very briefly is as follows: The parison mold reciprocates on long horizontal bar-gibs which tip downward into a working hole in the tank and presses the mouth of the mold against the glass which is then sucked up until the ring mold on top of the blank mold is full. The mold then rises and a knife cuts the glass to the exact volume and supports the blank from underneath. After the preparatory blowing and cooling, the wings of the parison mold open, and suspended from the ring mold the blank is lowered into the finishing mold. In the B model, it is blown to final shape, and in the F model, a vacuum is created in the forming mold which lets atmospheric pressure expand the blank into finished shape. The bottom of the finishing mold is a separate plate which tips over automatically and the ware slides on suitable chutes to the transport belt or conveyor. Only one parison mold and one blow mold are used. The type "F" machine will produce from 50 to 100 gross, according to size, while "B" machine will produce 20 to 35 gross.



The Roirant Bottle Blowing Machine

CATALOGS RECEIVED

Sil-O-Cel C-22 Brick. Johns Manville, New York. A new folder dealing with the use of this brick as a combination refractory and insulation for temperatures up to 2000° F. Contains complete engineering information, including data on conductivity, strength, permeability, expansion, deformation under temperature and resistance to spalling. Charts and tables show the effect of C-22 in reducing both heat transmission and heat storage losses.

J. M. Superex Blocks. Engineering folder IN-28-A. Johns Manville, New York. Gives data on the new 1900 degree Superex Insulating Blocks and discusses the principles of Combination Insulation. The careful selection of two or more insulating materials in a furnace or boiler wall not only assures more economical operation but in many cases results in lower construction costs. Tables are included covering recommended thicknesses of Superex both when used alone and in combination with other insulating materials.

Jena Fritted Glass Filters and Apparatus. Bulletin 232 LE. Also *Jena KPG Precision Bore Tubing.* Bulletin 4548 E. Fisch-Schurman Corporation, New York, N. Y. Data, prices and specifications covering these products of Jena Glass Works, Schott & Gen. Jena.

Utility Air Hosts. Bulletin No. 12107 Ingersoll-Rand Co., New York. Describes both the single and double-drum air hoists and their uses in industrial service. Profusely illustrated and contains many tables of engineering data useful in connection with this type of equipment.

Scientific Mixing. Bulletin 70-B. Lancaster Iron Works, Lancaster, Pa. A discussion of mechanical mixing in relation to the "Lancaster" Mixing System. Contains a great deal of dimensional and operating data, with illustrations, diagrams, etc.

Firing Method Modernized for Profit. Link-Belt Company, Chicago.

A comparison of hand firing and controlled automatic underfeed firing of boilers from 10 to 250 B.H.P. Such features as smoke elimination, uniform temperatures and pressures, coal savings, firing efficiency, etc., are illustrated in graphic and pictorial form. Copies may be had by writing the Link-Belt Company, Chicago.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks ... Per 100 lb.	lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 38° carboy ext.	Per 100 lb.	3.50	...
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	... Po. or Gr. / Cry.	.25 / .25½
Alcohol, denatured	gal.	..	...
Aluminum hydrate ($Al(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.05¼	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	.15¼	.16
Ammonia water (NH_4OH) 26° drums	lb.		.02¾
Antimonate of Sodium	lb.	.09-.09¼	.10
Antimony, metallic (Sb)	lb.	.02½	.02¾
Antimony oxide (Sb_2O_3)	lb.	.08¼	.09
Antimony sulphide (Sb_2S_3)	lb.		.07
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.04	.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite)			
90%, 99% through 200 mesh	ton	56.50	61.50
90% through 100 mesh	ton	44.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.05	.05¾
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.08¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash, carlots	lb.	.06	.06½
Borax ($Na_2B_4O_7OH_2O$)	lb.	...	...
Granulated ... In bags,	lb.	.02	.02¼-.02½
Powdered ... In bags,	lb.	.02¼	.02½-.02¾
Boric acid (H_3BO_3) granulated ... In bags,	lb.	.04¼	.04½-.04¾
Cadmium sulphide (CdS)—	lb.	...	.70-.75
Chromite	lb.	...	.215
Chrome oxide Green	lb.	...	.215-.25
Cobalt oxide (Co_2O_3)			
In lbls.	lb	..	1.25
In 10 lb. tins	lb.	...	1.35
Copper oxide			
Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.17-.19
Black prepared	lb.	...	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08	.085
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.40
Feldspar—			
40 mesh	ton	10.50-12.75	
20 mesh	ton	10.00-12.25	
Granular	ton	10.75-13.00	
Semi-granular	ton	10.00-12.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags.			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	28.23-35.00	...
In bags	ton	29.83-36.60	40.60
Imported (f.o.b. Seaboard)	ton	31.00	...
Formaldehyde	lb.	.05	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	..
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead)	lb.	.065	...
In 5 Ton lots	lb.	...	.07
Less than 5 Tons	lb.	...	.075
Litharge (PbO)	lb.	.055	...
In 5 Ton lots	lb.	...	.06
Less than 5 Tons	lb.	...	.065
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	..
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.15	2.30
Limestone ($CaCO_3$)		1.75-2.50	...
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.03
Manganese, Black Oxide			
In Paper bags	ton	45.00	...
In Burlap bags	ton	46.50	51.50
In Casks	ton	48.00	53.00
Nickel oxide (Ni_2O_3), black— for nickel content	lb.	...	.35-.40
Nickel monoxide (NiO), green— for nickel content	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00 29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	.08½	.08½
Powdered	lb.	.08½	.09½
Potassium carbonate	lb.	.0825	.0875
Calcined (K_2CO_3) 96-98%	lb.	.07⅞	.0875
Hydrated 80-85%	lb.	.07¾	.0775
Potassium chromate (K_2CrO_4)	lb.		.14¼
Potassium hydrate (KOH) (caustic potash)	lb.	.07½	.09
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	.18½	.19
Powder blue	lb.	...	.18-.45
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	... Po. or Gr. / Cry.	.13½
Rutile (TiO_2) powdered, 95%	lb.	.15-.20	.20-.25
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se)	lb.	...	1.80-2.00
Silver nitrate (AgNO)	(100 oz.) per oz.	...	.31
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.06½
Sodium fluosilicate (Na_2SiF_6)	lb.	.04¼	.05-.06
Sodium hydrate (NaOH) (caustic soda)			
Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	lb.	...	2.25-2.50
95 per cent	Per 100 lb.	1.195-1.295	1.245-1.345
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Yellow or Orange	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.45	3.70-4.05
Flowers, in bags	Per 100 lb.	3.10	3.35-3.65
Flour, heavy, in bbls.	Per 100 lb.	2.85	3.20-3.45
Tin chloride ($SnCl_2$) (crystals) in bbls.	lb.	...	.38-.385
Tin oxide (SnO_2) in bbls.	lb.	...	.57-.60
Uranium oxide (UO_3) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	2.75
Yellow orange	lb.	...	1.55
Zinc oxide (ZnO)	lb.	.08½	.12
American process, Bags	lb.	.065	.0675-.075
Zircon			
Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude, Gran. (Milled .005-.02c higher)		.03½	.04-.05

FOREIGN TECHNICAL PAPERS

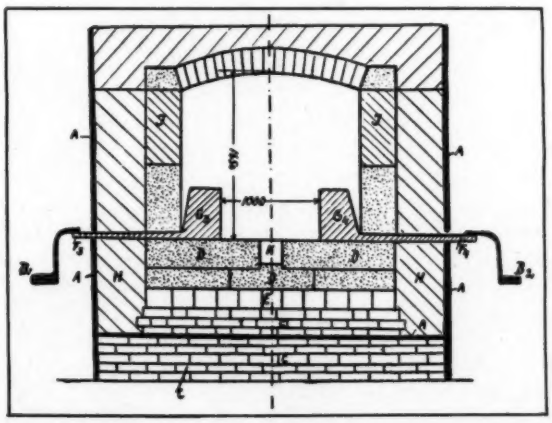
TRANSLATION By S. R. SCHOLES

ELECTRICAL GLASS MELTING (*Continued**)

Cornelius[1] developed his electric furnace about the same time as Raeder's work. He used direct resistance-heating, employing heavy electrodes of very pure iron, lying on the tank-bottom. The stream of glass flowed from the charging end between four pairs of electrodes, in a narrow channel. The colder glass above the electrodes protected the wall.

After making glass for bottles in his furnace for more than a year in Sweden, Cornelius built a tank of 5 tons daily capacity for Pilkingtons at St. Helens, England. The operation of this tank was reported to the Society of Glass Technology by E. Meigh, 1931. At times the glass was of good color and comparatively clear, but not continuously. The furnace showed promise for colored glass.

It is remarkable, when one considers the furnace contains 3 tons of iron electrodes, that such progress was made toward the production of crystal glass.



Experimental Furnace at St. Helens. G, Electrodes. F, Conductors. B, Bus-bars. J. Side-walls. A, Steel work. C, Masonry. K, Canal in bottom of melting chamber.

Results of Raeder and Cornelius are held to demonstrate the practicability of electrically heated tanks.

Hitner (U. S. A.) and Holmgen (Sweden) are mentioned only by name. The furnace built in Italy by Brown, Boveri, & Co., is to be described later.

Horowitz calculates the energy-requirements of a glass furnace heated by fuel, using a formula:

$$B_t = B_o + \alpha P + \beta P^2.$$

For the electric furnace $\beta = o$, and we have

$B_t = B_o + \alpha P$, in which:

B_t = total heat Cals., supplied to the furnace in 24 hours

B_o = heat required to run the empty furnace

P = glass production in 24 hours, kilos.

α and β are constants.

P is usually reckoned in tons per square meter per 24 hours or Kg/m²/hr. But this does not apply to the electric tank, in which not merely the surface layers, but the entire moving body of the glass is heated by the current. The idea of a yield-factor is brought in, meaning the ratio of glass produced to the total content of the tank. A table is presented:

	Production t/m²/24 hr.	Yield-Factor f
Tanks fired with producer gas ...	0.35—0.7	0.14—0.2
Ordinary oil-fired tanks	0.75—1.0	0.33—0.4
American high-duty oil-fired tanks	1.25—1.8	0.5 —0.6
Electrically heated tanks		1.0

The fuel-consumption K in calories per kilogram of glass melted is

$$K = \frac{B_t}{P}$$

Let f = yield-factor

W = content of tank in kilos. glass

n = furnace-efficiency in per cent

and the following equations hold:

$P = f.\ W$ kilos.

$$n = C \text{ (a constant) } X \frac{100}{K}$$

Substituting: $$K = \frac{B_o}{P} + \alpha = \frac{B_o}{W} \cdot \frac{1}{f} + \alpha$$

$$\frac{1}{n} = \frac{B_o}{C.W.100\,f} + \frac{\alpha}{C \cdot 100}$$

From these equations it follows that not only the relation between heat applied and tonnage; that is, yield-factor, but also that between furnace efficiency and tonnage, again yield-factor, may be represented graphically by an equilaterial hyperbola.

Let us make a comparison, as to data: Figures from English and American sources refer to the melting-area in its true sense, because the bridge-wall construction common in those countries provides a real separation between melting and working chambers. But German data more often refer to the entire area of the tank, since there is no definite partition of space, especially in older designs. In order to get comparable figures, it is well to assume in the latter instance that the melting area is about two-thirds the entire area.

It is also to be noted, that the whole matter is bound up with specific load or "pull", that is, in an electric tank, with the raising of the yield-factor; it remains on this account the essential point in the improvement in fuel consumption (or current consumption) of melting furnaces, that batches that will melt more quickly and easily and at a lower temperature must be introduced and applied; for reduction of fuel for a given

* J Horowitz, Die Glashütte, 1934, No. 15.

[1] Brit. Pats. 249,554 and 303,798.

tonnage cannot be accomplished by technical improvements in construction alone. One of the great strides in this direction was to go from salt-cake to soda-ash in batch-compounding. Research on glass depends upon research on new refining agents, as for example ammonium sulfate, borax, boric acid, and others.

The distribution of heat-balance for a well-operated bottle-glass tank may be given for illustration as follows:

	Cal./Kilo.	Btu./lb.	%
For melting the glass	570	1025	20
Lost in stack-gases	715	1285	25
Lost through the crown	425	765	15
Lost through side-walls	200	350	7
Lost through the bottom	200	360	7
Lost in Recuperators and flues	680	1225	24
Radiation from work-holes	60	110	2
Total heat expended	2850	5130	100

It is evident that the balance of a good furnace has been selected, in order to gain some insight into the possibilities of electrical melting with the above figures in view. The specific load was 0.91 t/m²/24 hr.*, and the yield-factor 0.35.

With an electric furnace, we may drop from the losses in the above heat-balance the following:

(a) Those caused by the hot gases leaving the furnace.

(b) Those which arise from sting-outs, conduction, radiation, and convention from those parts of the structure which are omitted from the electric furnace.

The losses remaining are those from heat escaping by any means through crown, side-walls, bottom, and work-holes. Hence appears a current-consumption of 1.7 Kwh if the yield-factor is only 0.35, and if this factor is 1.0, only 1.02 Kwh per kilo of melting glass will be necessary—assuming as before 570 Cal. as the heat for melting 1 kilo.

(to be continued)

*About 10.5 sq. ft. per ton of 2000 lb.

The Overmyer Mold Company, Winchester, Ind., has increased the number of its employees 25 per cent in the last few months and there are now 250 individuals on its payroll. About half of this increase is attributed to decreased working hours and the remaining half to an increase in business.

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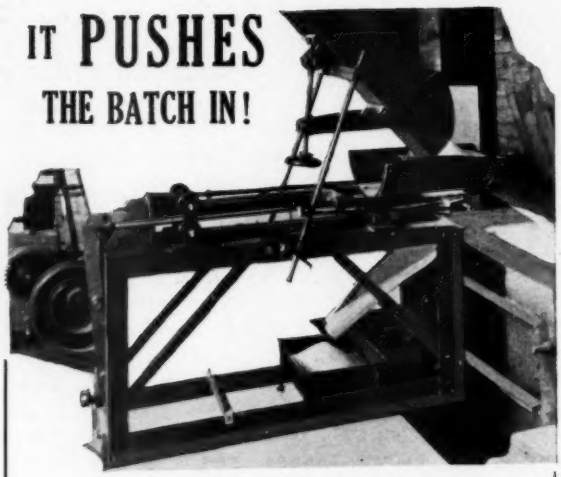

H-A BATCH CHARGER

The H-A Batch Charger assures exceptional uniformity of the chemical and physical properties of the hot metal. Not only does it gauge and feed the batch CONTINUOUSLY, but it PUSHES it under the mantle block in two diagonal directions, thereby uniformly spreading the batch in the melting end. Simple design; minimum maintenance cost.

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